INTELLIGENT
MICRO PATTERNING, LLC

SF-100 Platform Manual

Table of Contents

Part I

1 Legal Notices

Copyright Notice SF-100 Platform User's Manual

Warranty Intelligent Micro Patterning, LLC guarantees its products to be free of material and workmanship defects for one year from the date of shipment. This warranty is in lieu of all other guarantees expressed or implied and does not cover incidental or consequential loss.

INTELLIGENT
MICRO PATTERNING, LLC

Part II

2 Introduction

This document conveys all pertinent information needed to safely install, operate, and maintain Intelligent Micro Patterning's SF-100 Maskless Photolithography System. Performance, characteristics, specifications, and system configurations are subject to change without prior notice.

The SF-100 Series is an exposure system used in photolithographic processing. The key technology driving this system is Intelligent Micro Patterning's patented *Smart Filter*™ Technology.

2.1 Smart Filter Technology

Smart Filter™ Technology provides the user with the ability to perform photolithography processing without the need for expensive photomasks. The patented technology combines a number of optical and electronic components that project optical images onto the surface of substrates. Since poly-chromatic light is selectively filtered to provide this image, the name *Smart Filter*™ has been given to this technology.

Computer files of your design images are used to provide the necessary information for the Smart Filter. The necessary output data is furnished by using either the optional *Auto Stage*™ "load" function or other graphic image application's full-screen display in a pixel-based (rather than vector-based) graphics format such as bitmap (bmp). The input into the *Smart Filter*™ sub-assembly is a standard video signal from a personal computer (PC).

Output from the *Smart Filter*™ assembly is an optical image that is ultimately used to generate the photo-polymer exposure pattern onto the substrate surface. The *Smart Filter*™ sub-assembly incorporates the optics and electronics needed to ensure that this optical signal is:

- Uniform across the image
- Of high intensity for quick exposures
- Distortion-free to resolve small features on the electronic substrate.

2.2 The SF-100 XPRESS Maskless Photolithography System

The SF-100 Maskless Photolithography System was developed in order to provide a complete exposure processing solution to device manufacturers. The system incorporates *Smart Filter*™ Technology to

provide maskless exposures onto electronic substrates, and the *Auto Stage*™ software to make setup quick and easy. A block diagram and top view of the SF-100 Platform is shown below (*see Figure 2.2.1 and 2.2.2*).

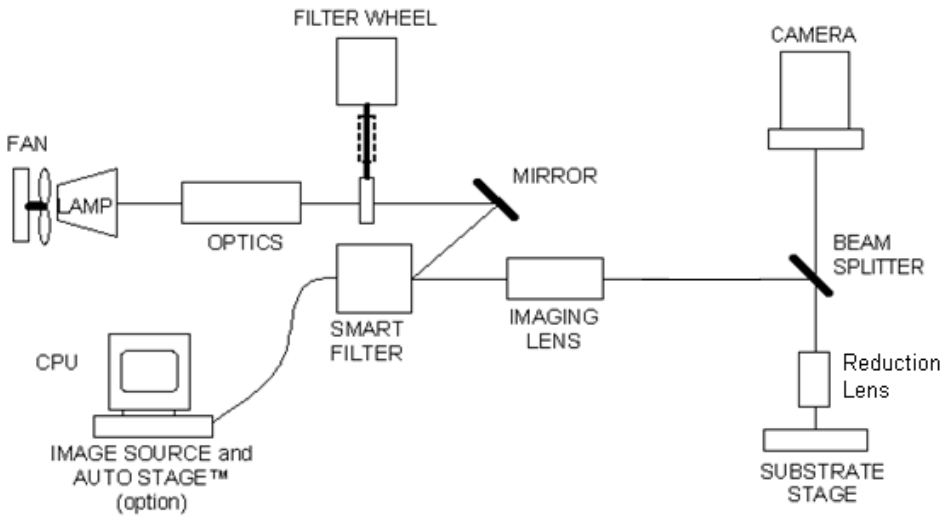


Figure 2.2.1: Block Diagram of SF-100 Maskless Photolithography System

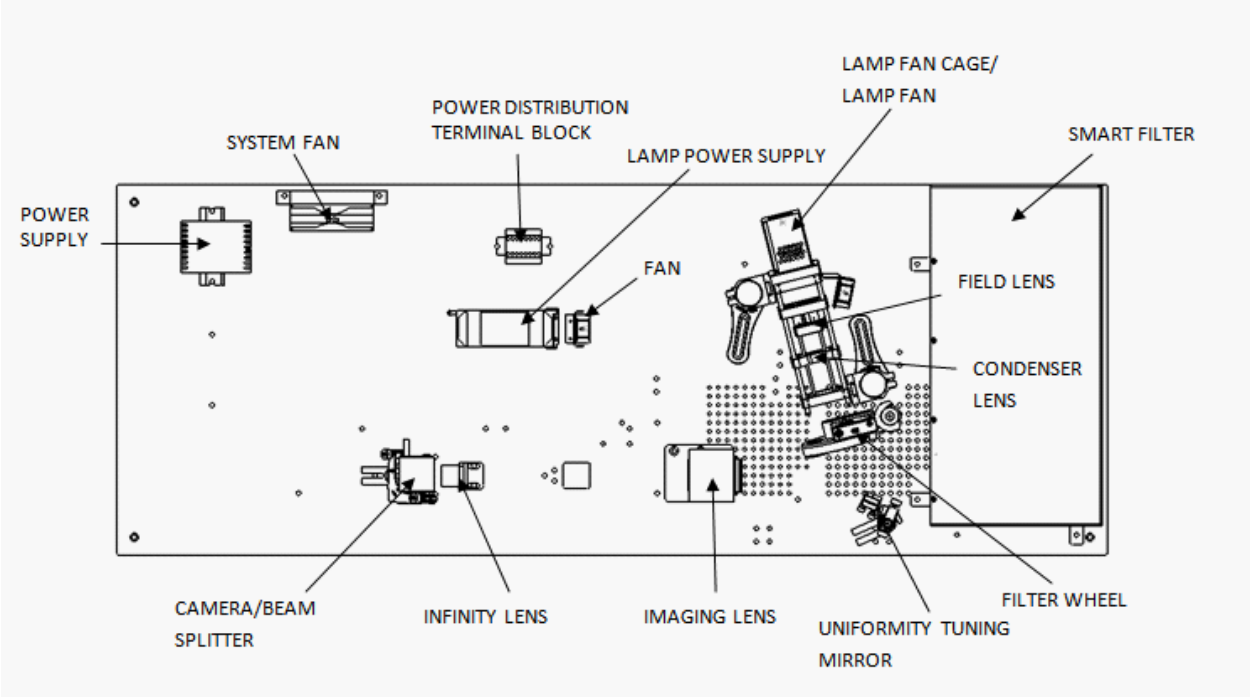


Figure 2.2.2: Internal Top View of the High Resolution SF-100 Photolithography System

The SF-100 Platform is an elegantly simple exposure system that provides exceptional imaging quality for micro device researchers and fabricators. Light is introduced into the system using a poly-chromatic light source. A direct coupled optical delivery system ensures efficient transfer of this energy to the *Smart Filter*™ sub-assembly.

As stated earlier, the *Smart Filter*™ incorporates all of the necessary optical and electronic components needed to transfer an image onto the substrate. Using proven optical design techniques, the projected image is free of distortion and uniform throughout the exposure area.

A standard Windows™ based personal computer is interfaced directly to the *Smart Filter*™, providing system control and image storage for the exposure process. The automated stage works with the computer to take all the calculations and guesswork out of making multiple aligned exposures.

Light from the *Smart Filter*™ is projected directly onto the surface of the substrate, which is secured to the stage. Since the area of this image may be less than the total desired exposure area, a step and repeat motion is used to expose substrate surfaces larger than the field of view. The *Auto Stage*™ software enables full automated setup, calibration, and execution of these activities. Manual overrides are also available on the *Auto Stage*™ software to facilitate unique applications and/or new/ experimental processes.

By using a beam splitter and a camera, the user may verify and control image-to-substrate alignment. This provides the SF-100 System the capability of fabricating multi-layer devices. A UV filter (internal to the SF-100) automatically removes UV energy from the target image to avoid substrate exposure during image-to-substrate alignment. This filter is necessary in order to prevent the photoresist from exposing while the substrate is being aligned to the image. The filter is lifted out of the light path during exposure using a software controlled filter wheel. The *Auto Stage*™ software is capable of configuring single and multiple programmed shutter operations.

2.3 Typical Photo-resist Coatings

Please keep in mind that, while the following resists are typically used at Intelligent Micro Patterning for testing/tuning purposes, the SF-100 Platform is capable of exposing a wide array of resist coatings. Also, note that all claims of feature size were proven with the following Photo-resists:

Shipley 1805 (20x)

Shipley 1827 (4x, 10x)

For more information on these photo-resists please click the following link: Shipley 1800 Series.

INTELLIGENT
MICRO PATTERNING, LLC

Part III

3 Safety

This section describes safety information regarding installation, operation, and maintenance of the SF-100 Platform. Additional cautions and warnings are provided in the manual where applicable.

Familiarity with the following symbols will help avoid unnecessary risk while using or maintaining the SF-100 unit and its associated equipment. Users and maintenance personnel are encouraged to become familiar with the meanings associated with these symbols.

Symbol	Description
	Important information concerning the operation and maintenance of this unit has been provided in the product documentation. This information should be read carefully to reduce and avoid risk.
	Potentially hazardous levels of UV light energy are present in certain areas of the system.
	Surfaces may be hot in the area where this symbol is placed for some time after power is removed. Follow instructions in the manual to avoid injury.
	Protective eyewear is required when operating this equipment. Failure to wear this protective equipment during operation may result in permanent eye damage.
	Equipment is very heavy and may cause injury if not lifted properly. Some form of mechanical assistance shall be used to lift the unit to prevent potential injury.
	There are nearby areas where hand injury might happen if equipment movement is ignored. Always be aware that equipment may move unexpectedly.

3.1 General

The following section details general safety recommendations that need to be considered when working with the SF-100 Platform.

WARNING: Failure to follow safety procedures outlined in this document may result in lethal electric shock, burn, or UV energy exposure.

Potential hazards exist in any optical electro-mechanical environment. To prevent injury to personnel or equipment damage, ensure that the power is disconnected when performing any work on the system. Follow company, local, and government safety regulations. Keep unauthorized personnel out of the area when working on the equipment. Voltages supplied to and within certain areas of the system are potentially dangerous and can cause injury to personnel.


Use caution when working inside (and around) the light source. Direct eye exposure with high power optical energy can cause permanent eye damage. When working on the equipment near the light source or any area that may be exposed to this optical energy, it is recommended that you always wear approved safety goggles that provide protection from ultraviolet light.


Some surfaces of the SF-100 System and its remote equipment may become hot. Caution should be used when near any of these areas. A partial list of potentially heated areas includes those near the light source and the power supplies.


3.2 Installation/Maintenance

This section highlights safety precautions to be observed with the installation and maintenance of the SF-100 Platform. In order to maintain the system in sound operating order, and for personal safety, it is essential that the tool be installed and maintained properly and safely.

WARNING: Maintenance on this system is restricted to trained and qualified personnel only!

Safety Precautions to Be Observed:

- Use only original spare parts and assemblies provided by Intelligent Micro Patterning for maintenance and service work. This includes all process consumables. Using non-original spare parts can cause malfunctions. It may also result in serious or fatal injuries as well as extensive equipment damage.
- Properly dispose of toxic, flammable, or hazardous waste material which may be used during or may result as a consequence of maintenance to system components.
- Stage pinch points should be monitored when this system is functioning since movement may be automatically initiated.

Potential hazards exist in any optical electro-mechanical environment. To prevent injury to personnel or equipment damage, ensure that the power is disconnected when performing any work on the system. Follow company, local, and government safety regulations. Keep unauthorized personnel out of the area when working on the equipment. Voltages supplied to and within certain areas of the system are potentially dangerous and can cause injury to personnel.

WARNING: Keep foreign and/or flammable objects from falling into the system, particularly in the light path area. Failure to prevent these items from entering the system may cause inhibited performance, overheating, and fire.
WARNING: Do not tamper with supplementary cover interlock switches to enable system operation without the covers in place. The cover protects the user from hazardous levels of ultraviolet light, which may cause permanent eye damage, and from hazardous voltages which may cause shock, burn or death.
WARNING: Do not place any non-approved optical components into the light path. These may redirect light within the unit and can cause unpredictable outcomes such as eye injuries or even fire.

3.3 Handling

This section lists some recommended handling safety tips for installation and/or maintenance of the SF-100 equipment.

The SF-100 Platform is very heavy, and lifting or moving the unit without mechanical assistance may cause personnel injury.

- Use talc-free, oil free, and lint-free gloves when working inside (and around) optical components and the process area. Fingerprints can cause contamination during processing or distort the optical image as it is projected through the light path.
- Make sure that any components which are removed are properly contained when being discarded or stored.
- Follow all company, government, and local safety regulations/laws/guidelines for protecting personnel, equipment, the facility, and the environment.

3.4 Electrical

This section describes warnings and cautions for working with the SF-100 Platform electrical sub-system in general. Power shall always be disconnected before opening any enclosures or changing any cables or connections.

If any wires or cables appear damaged, contact Intelligent Micro Patterning immediately to determine the appropriate course of action. Care should be taken when making power connections and interconnections between sub-assemblies in the system. Interconnections shall be made with systems powered-off to reduce danger to personnel as well as equipment damage. For your protection, supplemental cover interlock switches have been designed into the system to further reduce the likelihood of exposure to hazardous voltages when the cover or lamp access panel is removed. Do not tamper with these switches to allow system operation without the cover and/or panel in place. Voltage levels exist within the system that present a lethal shock hazard.

3.5 Optical

This section describes warnings and cautions for working with the SF-100 Platform optical sub-system. It also suggests safe practices for working with the optical components.

CAUTION: The lamp must be changed at the appropriate interval as described in the "Maintenance" section of this manual. If you continue to use the lamp after 1500 hours, the lamp bulb may shatter and pieces of glass may be scattered in the unit. Do not touch these pieces of glass as they may cause injury. If this occurs, contact Intelligent Micro Patterning for further instructions and lamp replacement.

- To effectively clean the lenses internal to the *Smart Filter*™ light path, they must be removed from the system. Please contact Intelligent Micro Patterning for assistance in removal, cleaning and replacement of these components if necessary.
- Whenever cleaning optical components, use only lens paper to avoid scratching or marring the lens. If dry lens paper is not effective in cleaning the lenses, methanol may be used.
- Ultraviolet (UV) energy at 365nm, 435nm, and a broadband from 350nm to 550nm are present in the light used during exposure.

WARNING: Protective eyewear shall be worn when viewing the substrate area during exposure. Viewing the substrate area during exposure is strongly discouraged to avoid eye discomfort and possible eye damage.

INTELLIGENT
MICRO PATTERNING, LLC

Part IV

4 Installation

The following procedures should be used to install a new SF-100 Maskless Photolithography System. The procedures shall be performed by an Intelligent Micro Patterning Field Service Engineer or by the customer *with written pre-approval from Intelligent Micro Patterning and proper training*.

4.1 Site Requirements

In order to obtain the maximum benefit and process results from the SF-100 Platform, the following requirements shall be made available to the system at the installation location.

- Anti-vibration table or breadboard for the optical body of the system and the stage assembly to rest upon. The computer and other free standing subassemblies should not rest upon this table in order to minimize any vibration transmission from these components to the main system body. They should be placed in the designated locations on anti-vibration table.

- Since the majority of maintenance activities are made from the rear of the unit, 24 inches (610 mm) of free space should be left around the perimeter of the main unit. This will also ensure adequate ventilation for system operation (*see Figure 4.1.1*). The system location should allow enough room to remove the top panels to gain access to the top of the system.

  Note: The chassis shown in Figure 4.1.1 is an example to show proper spacing and may not reflect the system that is received, refer to the "Mechanical Drawings" section to look up the appropriate chassis dimensions.

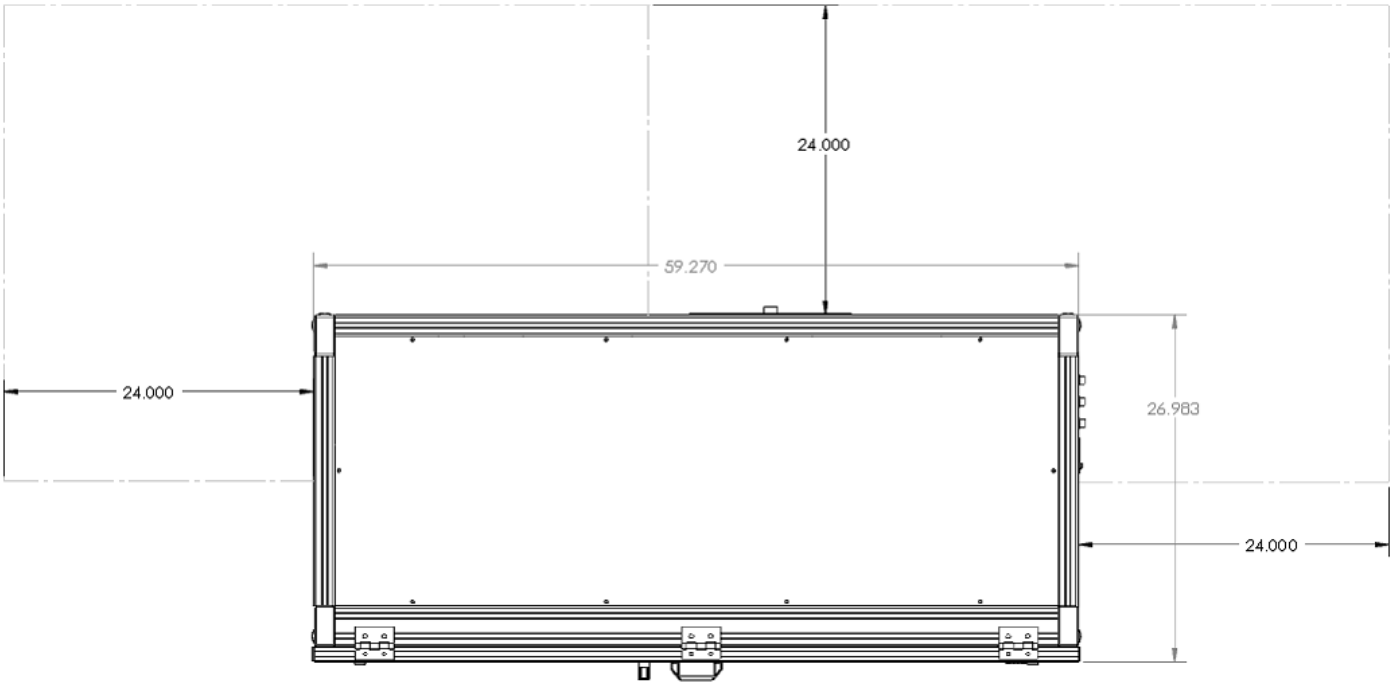


Figure 4.1.1: Top View of SF-100 Example Chassis showing installation spacing (units in Inches)

Environmental Requirements

The system user (purchaser) is to provide a clean room facility with the characteristics mentioned below for successful operation of the SF-100 Platform. These must be maintained during system operation in order to obtain repeatable process results. Connections between the IMP system and these facilities will be made by the IMP field service engineer before system startup and testing.

- +/- 2^{o}C room temperature control
- 40-60% relative humidity non-condensing
- House vacuum for chuck: 26 inches (~660mm) Hg of vacuum with a flow volume of 2.5 SCFM (0.06 cubic meters/minute) @ 0” Hg
- Class 100 or better yellow room

- 5 standard line voltage receptacles (1 each for monitor, computer, optical train, motor controller, extra for maintenance activities), 110V, 50-60Hz. All standard US style grounded receptacles.

- Compressed air or nitrogen, >80psi, >1 CFM.

- Standard ethernet connection with internet access compatible with Windows 7™ operating system and the most current version of MS Internet Explorer™.

- 3" diameter connection on back of system for system exhaust. System exhaust to provide >1 CFM flow at standard room pressure to system to ensure mercury fumes are vented in case of a lamp failure.

4.2 Unpacking of Equipment

Inspect all enclosed items for visual damage. Any damage to crates, boxes, or materials should be documented using a camera and reported to Intelligent Micro Patterning immediately. Note any shipping damage and begin any appropriate replacement or insurance claim actions to correct. Please take photos of any possible damaged areas and email them to the Intelligent Micro Patterning Customer Service group within 24 hours after determination of the damage

Ensure all correct items are enclosed in each box. Packing slips will accompany each box shipped to the customer site. Each shipment should include the following sub-assemblies:

- **SF-100 System:** This will include the base supporting the optical path, light source, and other components housed in the main body. Additionally, the frame that supports this structure will remain partially attached to it during shipping.

- **Optical Table/Breadboard:** This is the lower base plate of the SF-100 Platform which will support the automated stage assemblies and the chassis of the system.
- **Stage Components:** Automated Stage parts include the automatic stage, Stage Controller Unit, and cabling.

CAUTION: Extreme care should be taken when handling the stages. While they are heavy and may appear very rugged, they are high precision components; subject to damage if mishandled.

- **Substrate Holder and Vacuum Pump (when applicable per PO).**
- **Windows-Based Personal Computer and Monitor:** This will be shipped in its original container. All support devices (e.g. keyboard and mouse) will be included with the computer.
- **Spare parts (if ordered)**

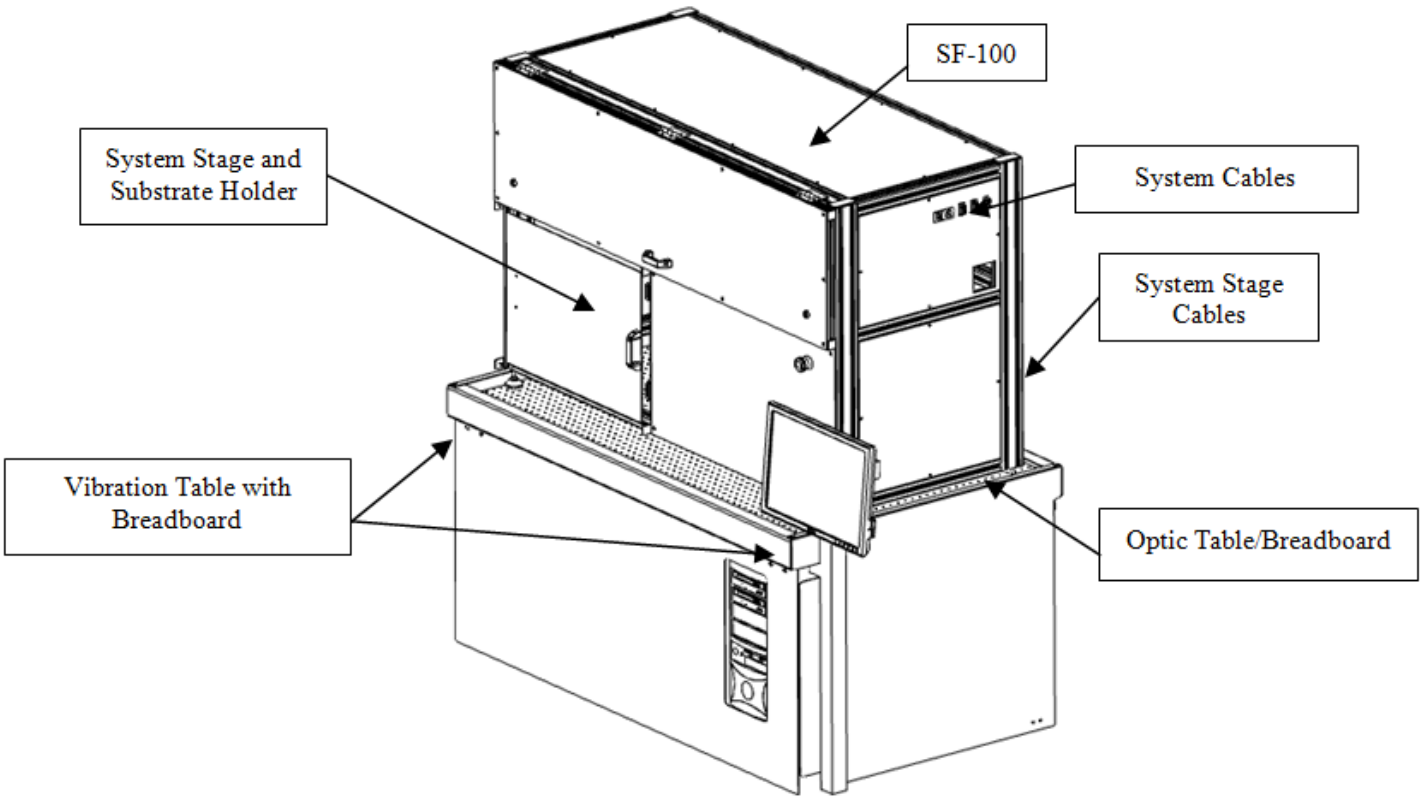


Figure 4.2.1: System Setup (Example system shown. The actual tool may vary according to model)

Unpacking the SF-100 Platform

The SF-100 Platform is not to be unpacked without a factory certified Intelligent Micro Patterning LLC field service engineer being present. The purchaser is responsible for supplying a technician to the IMP engineer to assist with the unpacking process. Unpacking and positioning of the SF-100 Platform is expected to take a maximum of 2 days (ie. 16 hours).

All major components of the SF-100 Platform will be bagged in clean room compatible plastic. After unpacking, the plastic wrapped subsystem is moved to the clean room staging area for wipe down prior to bringing the unit into the clean room. IMP will utilize the customer's cleaning procedure. The

purchaser is asked to provide all cleaning materials for this and a copy of the procedure to IMP at time of system purchase.

The order that the crates will be unpacked and moved into the clean room are:

Crate No.	*Major Assembly in Crate*	*Comments*
2	Vibration Isolation Table	Will require 2 additional people to move the table from the staging area into the clean room.
1	SF-100 Platform Tool Assembly	Will require 4 people to move to the table from the staging area into the clean room.
1	Stage Assembly	Will be carried by 2 people into the clean room. The granite must be placed under the tool first and then the automated stage.
3	Misc Items	Will be carried by 2 people into clean room after cleaning.

4.3 System Positioning and Connection

For proper positioning and connection of components:

- Using mechanical assistance to support unit weight, place the optical table with any attached adapter plates onto an appropriate anti-vibration pad.
- Place the computer tower on the floor or on the lower shelf of the anti-vibration table (if equipped with a lower shelf).
  Note: Do not place the computer tower on the breadboard of the anti-vibration table.
- Place the monitor on the monitor holder attached to the anti-vibration table.
- Place the automated stage control unit on the floor under the anti-vibration table.
- If equipped, connect the automated stage. The cables should exit from the back of the SF-100 Platform and connect into the controller.
- Connect the monitor video cable from the monitor to the video output connector labeled “1” on the computer graphics card.

- Connect the SF-100 DB9 serial port cable from the port labeled “SERIAL PORT” at the rear/ side of the unit to the mating serial port connector at the rear of the computer.
- Connect the SF-100 high density DB15 video cable from the port labeled “DATA PORT” at the rear/side of the unit to the secondary video output on the computer graphics card.
- Connect the power cords from the SF-100 Platform, Stage Controller Unit (if equipped), monitor, and computer into the four available wall outlets using the supplied power cords.
- Connect the SF-100 camera Firewire™ cable from the port labeled “CAMERA” at the rear/ side of the unit to the computer’s Firewire™ port.
- Connect the SF-100 filterwheel USB cable from the port labeled “USB Ports” at the rear/side of the unit to any open USB port on the computer.
- Connect the SF-100 autofocus lens USB cable from the port labeled “USB Ports” at the rear/ side of the unit to any open USB port on the computer (*see Figure 4.3.1*).

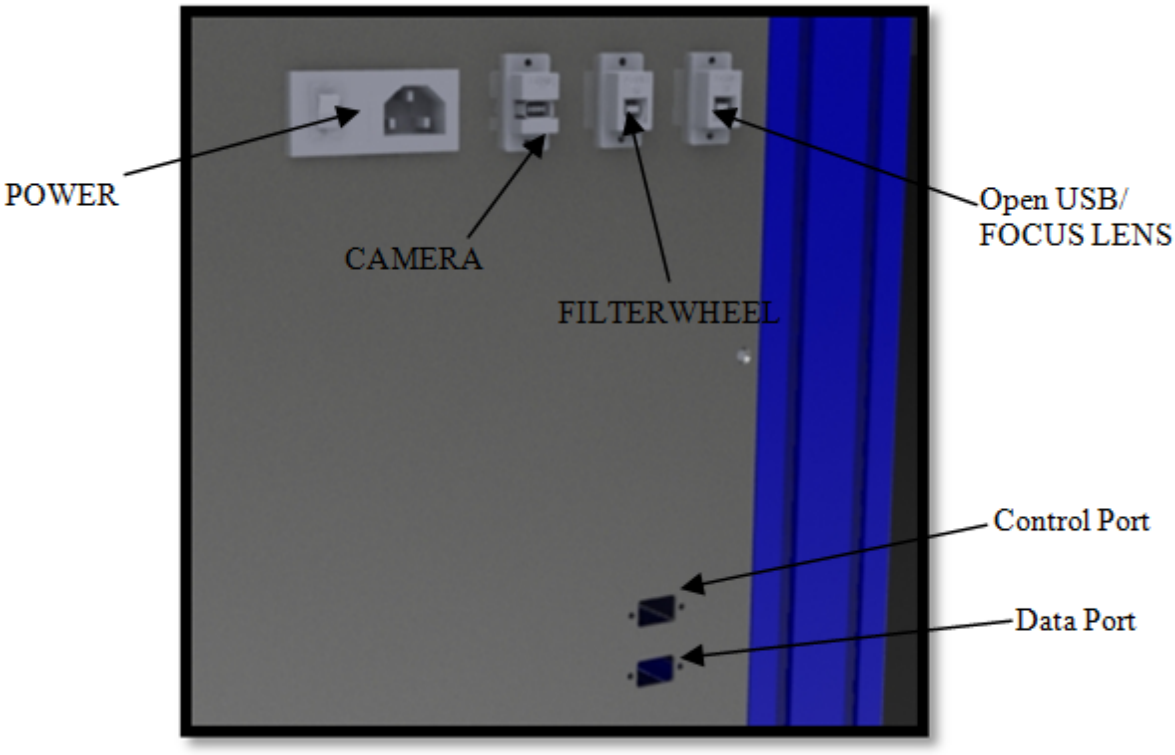


Figure 4.3.1: Cable connections on the right side top panel of the SF-100 Platform

INTELLIGENT
MICRO PATTERNING, LLC

Part V

5 Quick Start Guide

NOTICE: This guide assumes that the tool has been setup, tuned, and qualified by a trained IMP Field Service Engineer. If this is not the case please do not use this guide. Also, before continuing, be aware of all safety requirements. Unless you have undergone basic training by an IMP Field Service Engineer, please become familiar with the "*Auto Stage*™ Program Overview" before continuing with this guide.

5.1 Step 1: Power Up

1. Ensure all cords, cables, and unit covers are in place and all system vents are unobstructed. Turn on the SF-100 Platform using the switch located on the side of the unit next to the main power plug. You should hear the system fan turn on inside the unit and feel a discharge on the left rear of the unit. Lack of proper ventilation may shorten lamp life, cause system shutdown, or failure.

2. Verify that there is power going to the automated stage controller (if equipped).

3. Once the system fan and the filter wheel operation have been verified, turn on the computer and the monitor.

5.2 Step 2: Auto Stage Setup

1. Verify the Windows™ Desktop has the icons for *Auto Stage*™ by Intelligent Micro Patterning Note: If these icons are not located on the desktop, contact Intelligent Micro Patterning Customer Service for assistance.

2. From Windows™ Desktop, set the 2nd monitor (the SF-100 Platform) to extended desktop mode. To do this simply right-click the desktop to open a drop-down menu, then select "Screen Resolution." Under "Multiple Displays" select "Extend these displays." Finally, click "OK" to close the window and return to the desktop.

3. Start the *Auto Stage*™ program by double-clicking the icon on the desktop.

4. Input the User name and Password (default username and password are both "admin").

5. After logging in the “Load Settings” window will popup, select the appropriate profile (*see Figure 5.2.1*).

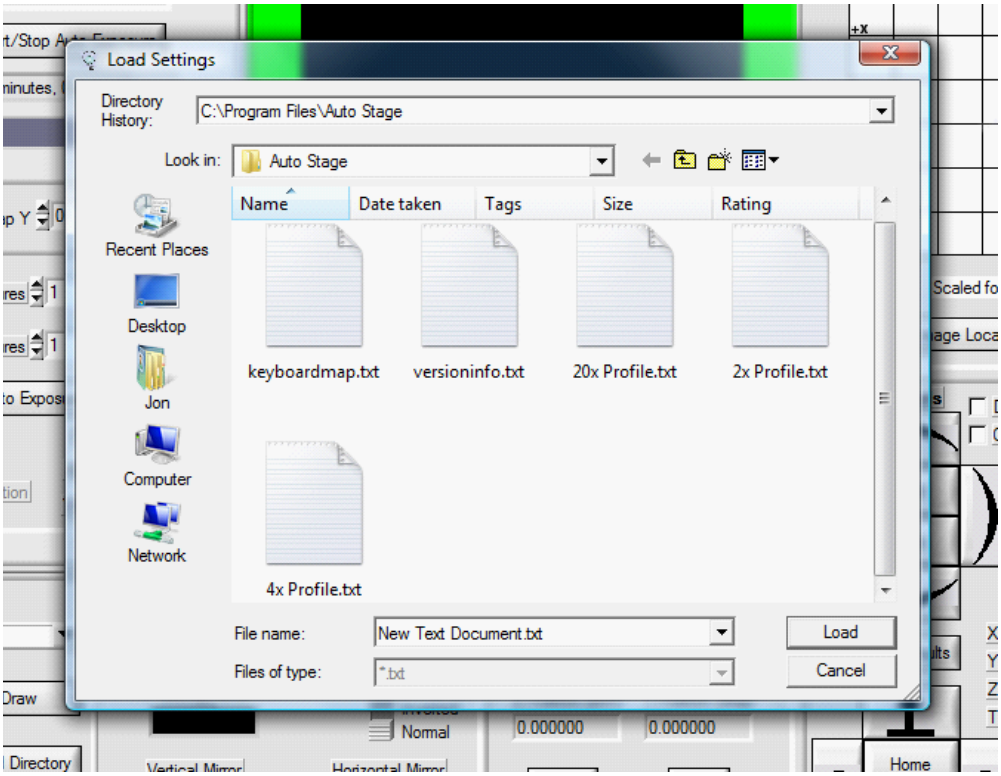


Figure 5.2.1: Load Settings popup

6. Direct your attention to the “Image Controls” section in the *Auto Stage*™ main screen for the steps below.

7. Select “Load Image” to begin browsing for the desired image or “Load Directory” to browse for a folder of images. Once the desired image/directory is highlighted, select “Load” again in the dialog window to bring the image into the "Image Preview" window.

   Note: Above the image display window, the “File History” drop-down will show the path to all images loaded during the session for quick selection and reloading.

8. In “Monitor List”, change monitor to “2” and left-click the “Draw” button. This will send the loaded image onto the *Smart Filter*™ and illuminate it onto the stage or substrate, but will not expose it yet.

   Note: Select the “Draw” button while “Monitor List” is set to “1” to have image appear in Full

Screen mode, where only the exposure frame portion of the full image will be viewable. To return to the Home Page screen, select the “ESC” key.

9. Finally, make sure the "Direct Control" button under the "Motion Controls" section is checked. You are now ready to expose!

5.3 Step 3: Exposure Setup

Before continuing the steps below, verify that the "Step 1: Power Up" and "Step 2: *Auto Stage*™ Setup" procedures have been completed.

1. Verify that the desired artwork is displayed in the "Image Preview" window (refer to "Step 2: *Auto Stage*™ Setup").
   Note: Remember that all components of the visible computer screen image will be exposed including any borders, menus or pointers. Clear the screen of all unwanted images before exposure. Also verify that the projected image at the substrate is oriented correctly; you may need to ‘flip’ the computer screen image to change the left-right mirrored orientation of the projected image.

2. Place your photo-reactive substrate on the stage under the exposure area.

3. Verify the projected image is in focus on the substrate. If not refer to "Image Focus/Z Stage Alignment"

4. Set the exposure timer for the desired exposure time.
   Note: A time series can be performed to test correct exposure time for a given substrate and resist (refer to "Executing a Time/Height Series").

5. Click on the “Start/Stop Auto Exposure” button located in the exposure controls for a single exposure.

   Note: Any auto exposure should be set up in the “Auto Expose Options”. Click on the “Auto Exposure Setup”, and the program will calculate the number of X exposures and the number of Y exposures. These can be modified to fit your needs. Make sure a value is selected for the overlap between exposures for the stitched shot. IMP recommends that a 20 pixel overlap be used (*see Figure 5.3.1*). After setting desired Auto-expose options simply click the “Start/Stop Auto Exposure” button (for more information refer to "Auto Exposure Options").

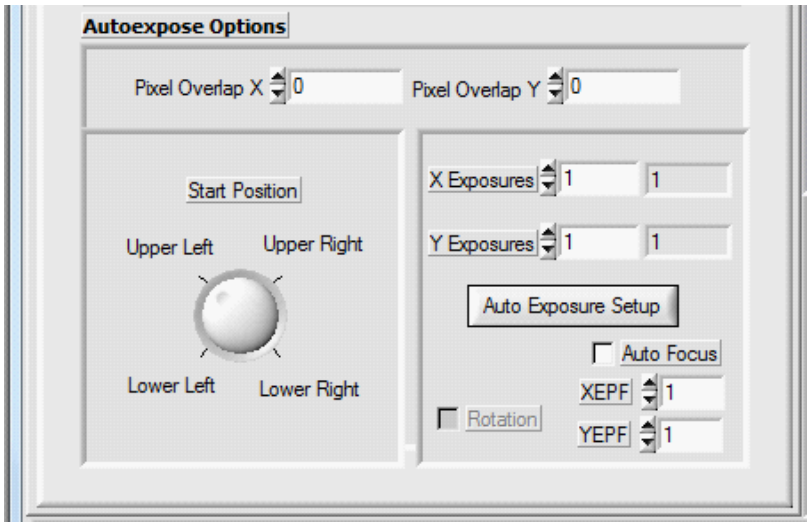


Figure 5.3.1: Auto Expose Options

6. Choose from the available options in the options menu and then click "Continue" (refer to "Start/Stop Auto Exposure Options").

7. The program will display a window alerting the user upon completion of the exposure. After completion the exposed substrate is ready to be developed and examined with a microscope.

   Note: Your developed substrate will vary in appearance depending on exposure and development times. You may need to experiment with both settings to achieve the desired results. Intelligent Micro Patterning has process engineers to assist you in your processing efforts. If you require assistance in this area, contact us for more information.

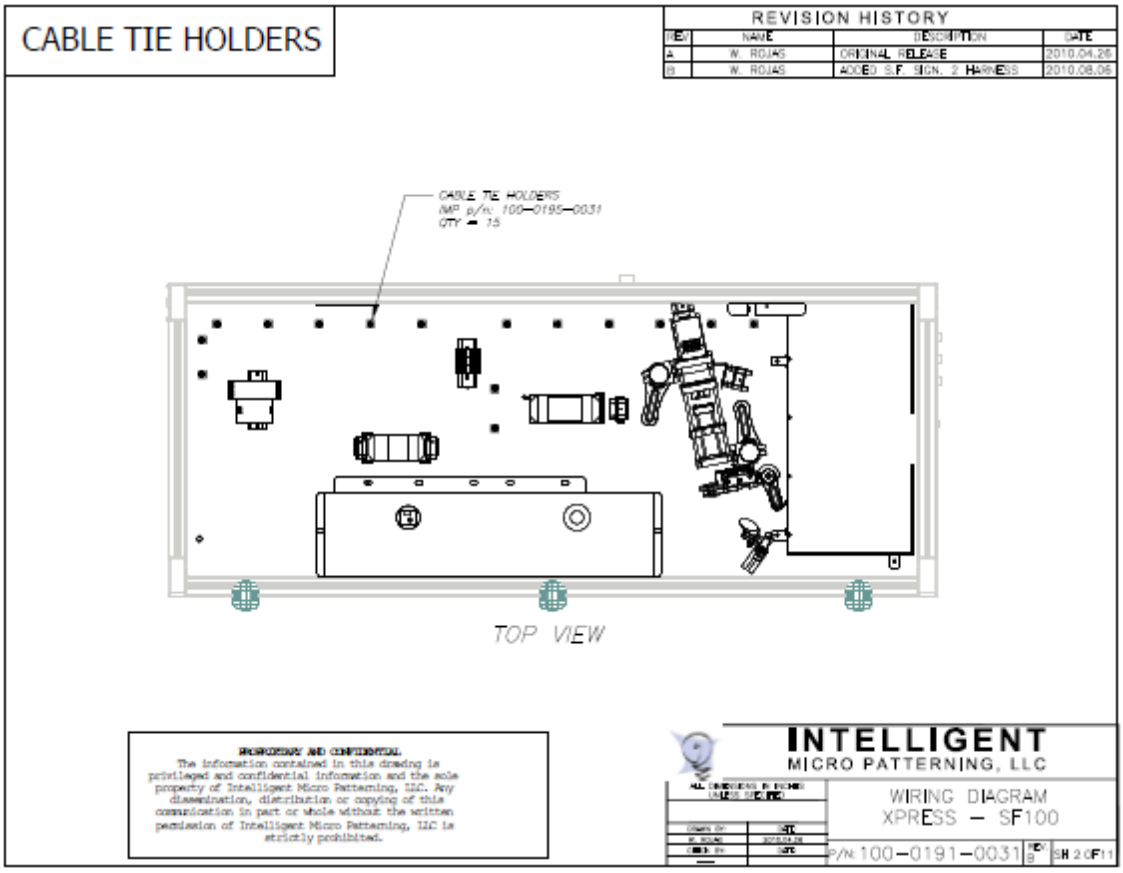
INTELLIGENT
MICRO PATTERNING, LLC

Part VI

6 Mechanical Drawings

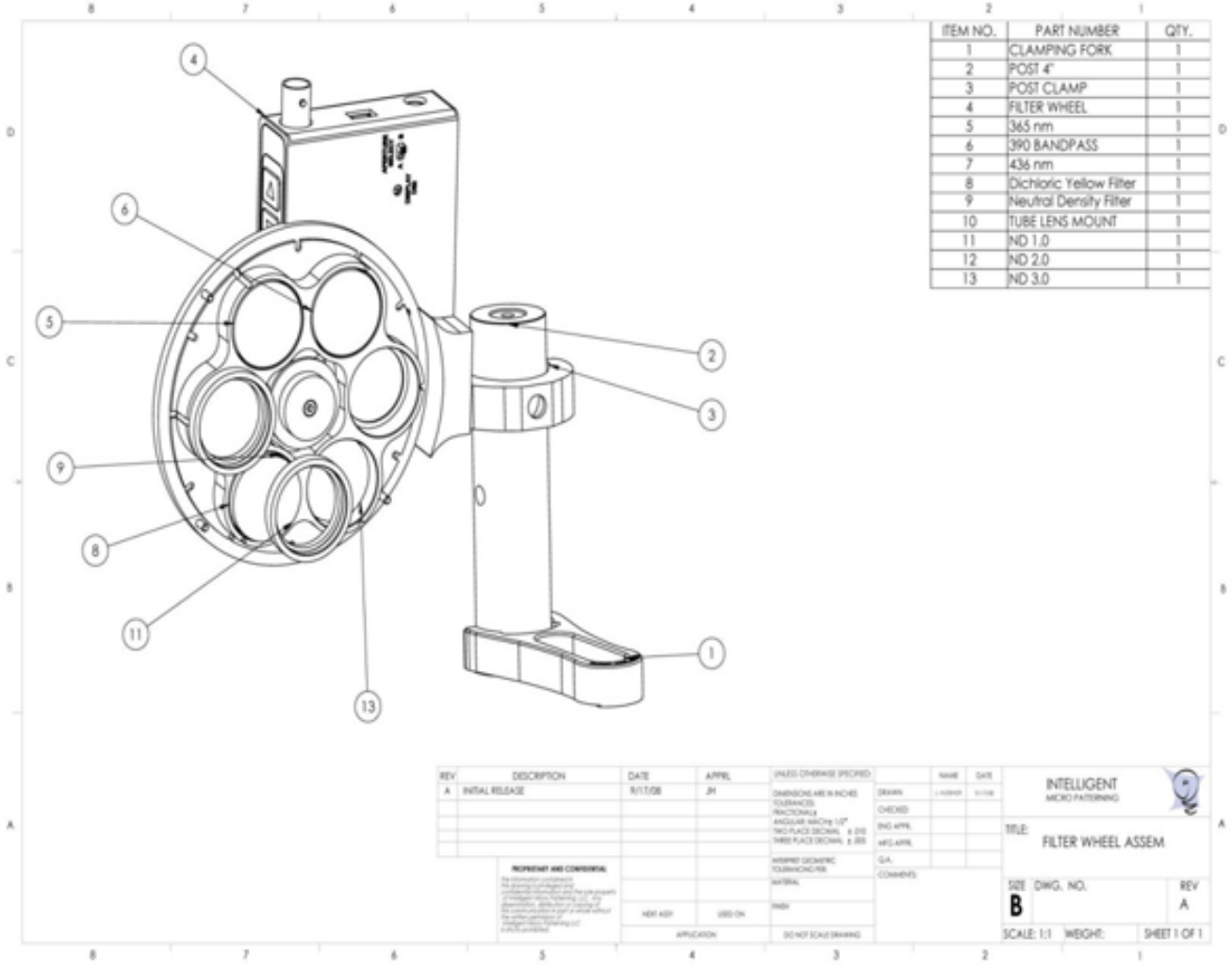
6.1 SF-100 XPRESS & XCEL

6.1.1 Wiring Diagrams XPRESS/XCEL

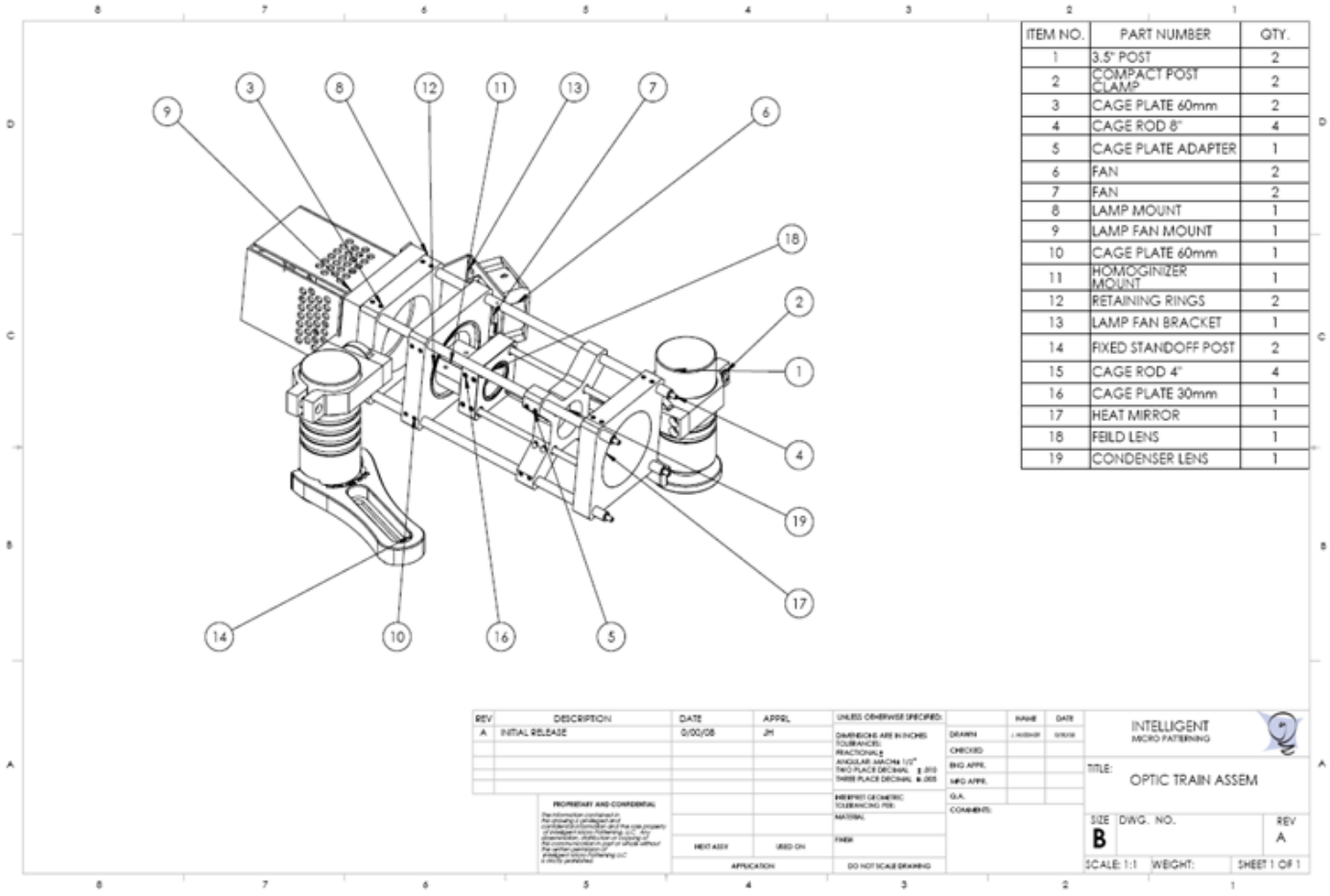


Double-Click On the Image Above to See Wiring Diagrams

6.1.2 Filter Wheel XPRESS/XCEL



6.1.3 Optical Train XPRESS/XCEL



ITEM NO.	PART NUMBER	QTY.
1	3.5" POST	2
2	COMPACT POST CLAMP	2
3	CAGE PLATE 60mm	2
4	CAGE ROD 8"	4
5	CAGE PLATE ADAPTER	1
6	FAN	2
7	FAN	2
8	LAMP MOUNT	1
9	LAMP FAN MOUNT	1
10	CAGE PLATE 60mm	1
11	HOMOGINIZER MOUNT	1
12	RETAINING RINGS	2
13	LAMP FAN BRACKET	1
14	FIXED STANDOFF POST	2
15	CAGE ROD 4"	4
16	CAGE PLATE 30mm	1
17	HEAT MIRROR	1
18	FEILD LENS	1
19	CONDENSER LENS	1

REV	DESCRIPTION	DATE	APPR.
A	INITIAL RELEASE	0/00/08	JH

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH± 1/2°
TWO PLACE DECIMAL ± .010
THREE PLACE DECIMAL ± .005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

NEXT ASSY | USED ON | APPLICATION

PROPRIETARY AND CONFIDENTIAL

INTELLIGENT MICRO PATTERNING

TITLE: OPTIC TRAIN ASSEM

SIZE B | DWG. NO. | REV A

SCALE: 1:1 | WEIGHT: | SHEET 1 OF 1

6.1.4 Smart Filter XPRESS/XCEL

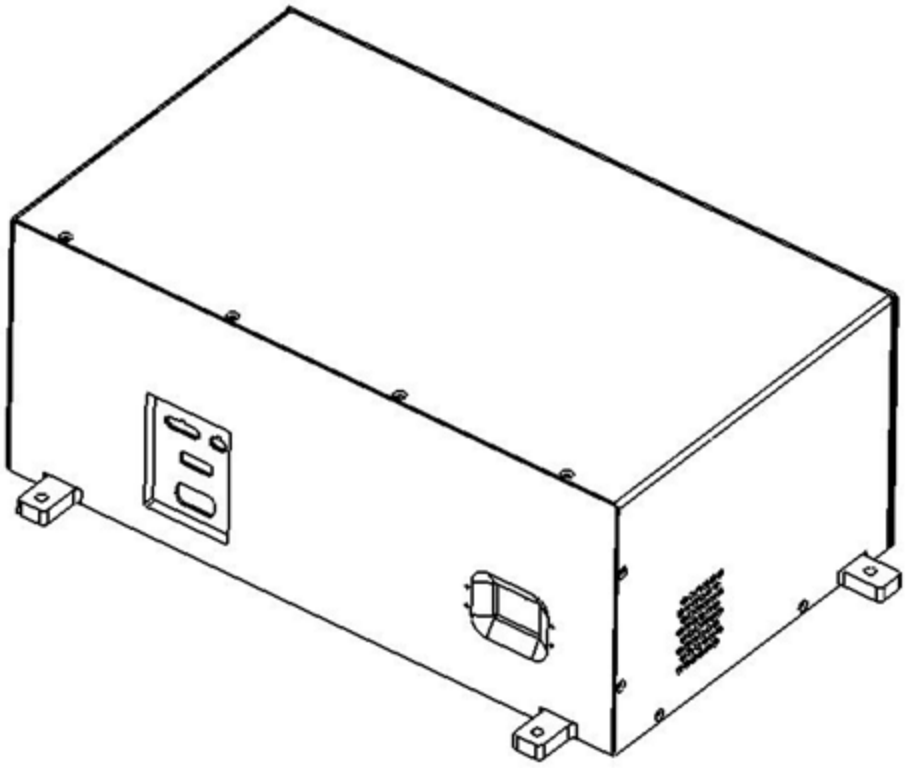


Figure 6.2.1: *Smart Filter*™ Enclosure

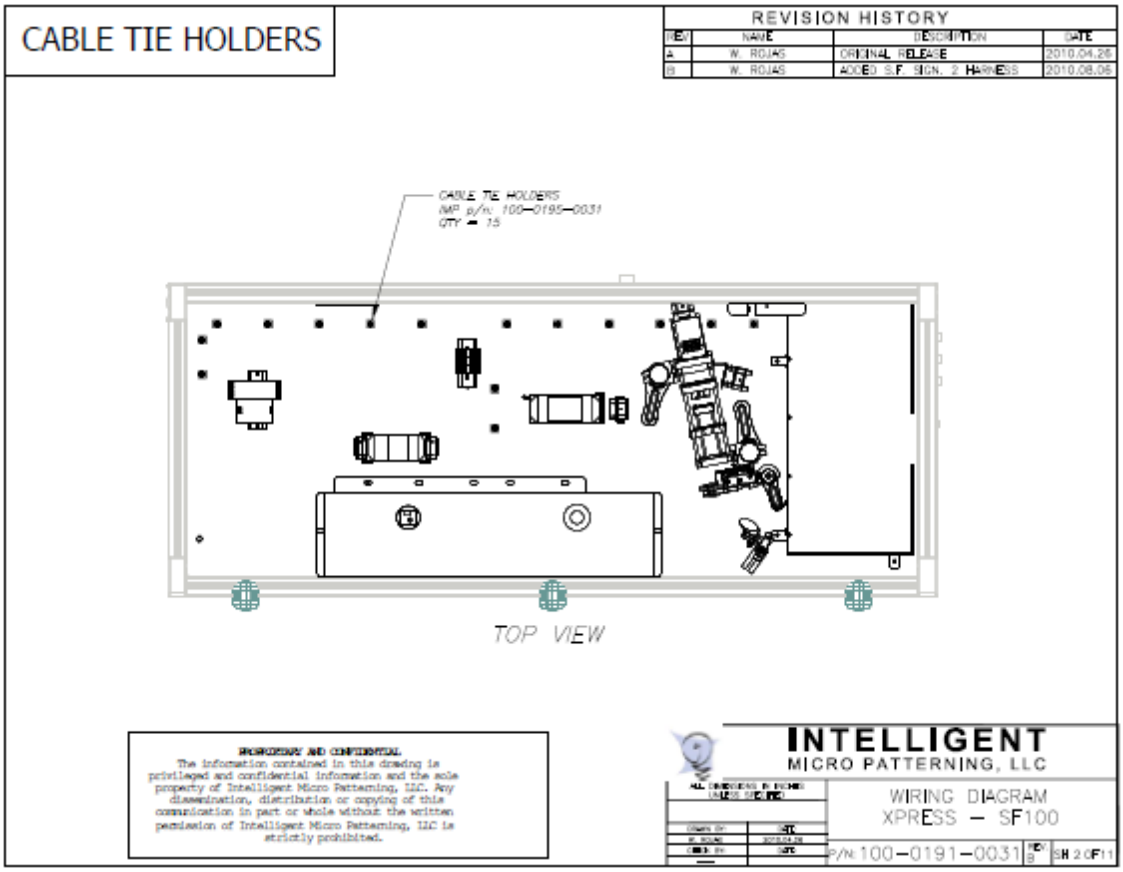
Note: The electronics used in the *Smart Filter*™ are proprietary and therefore cannot be shown.

6.1.5 Main Tool XPRESS/XCEL

Under Construction.

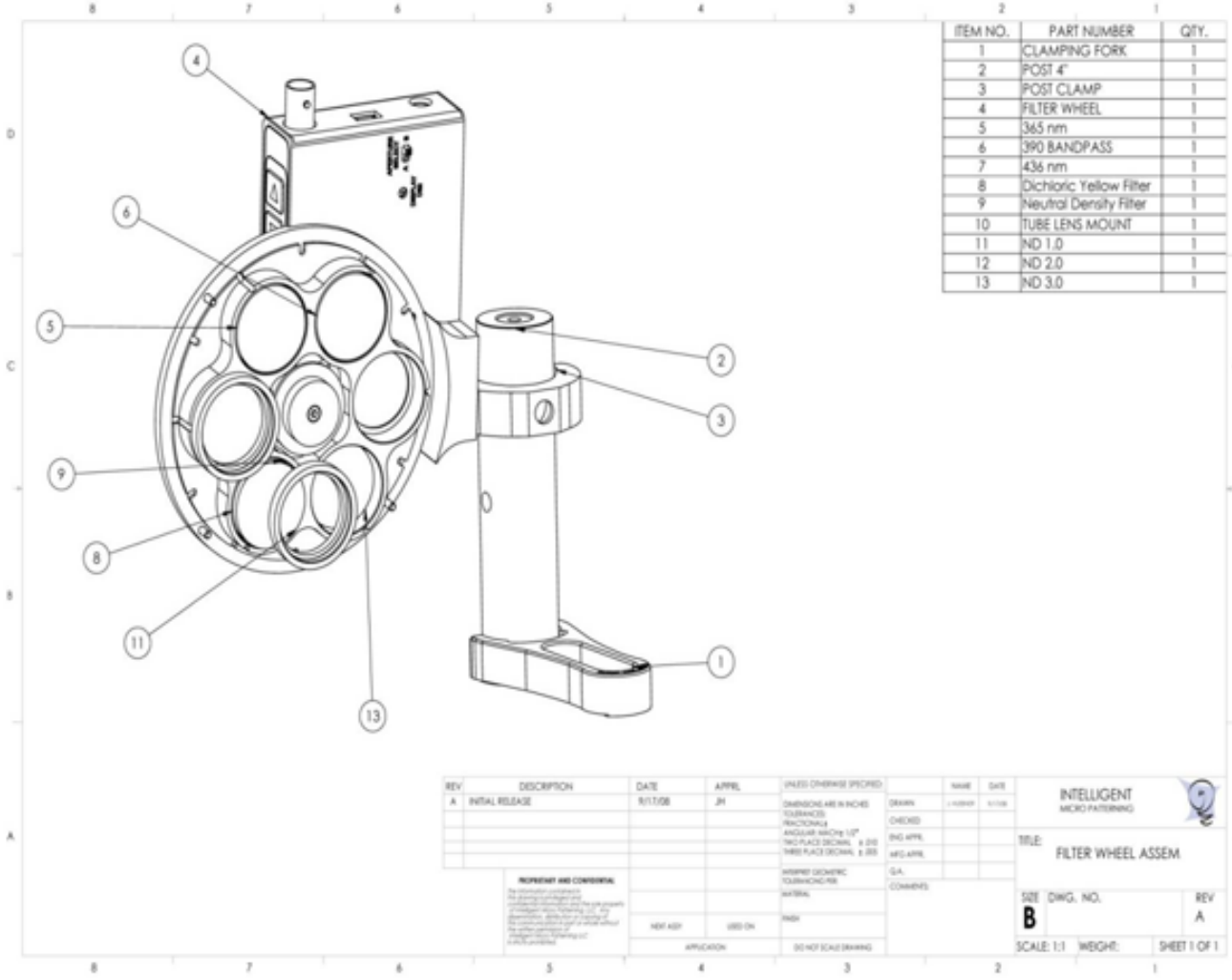
6.2 SF-100 XTREME

6.2.1 Wiring Diagrams XTREME

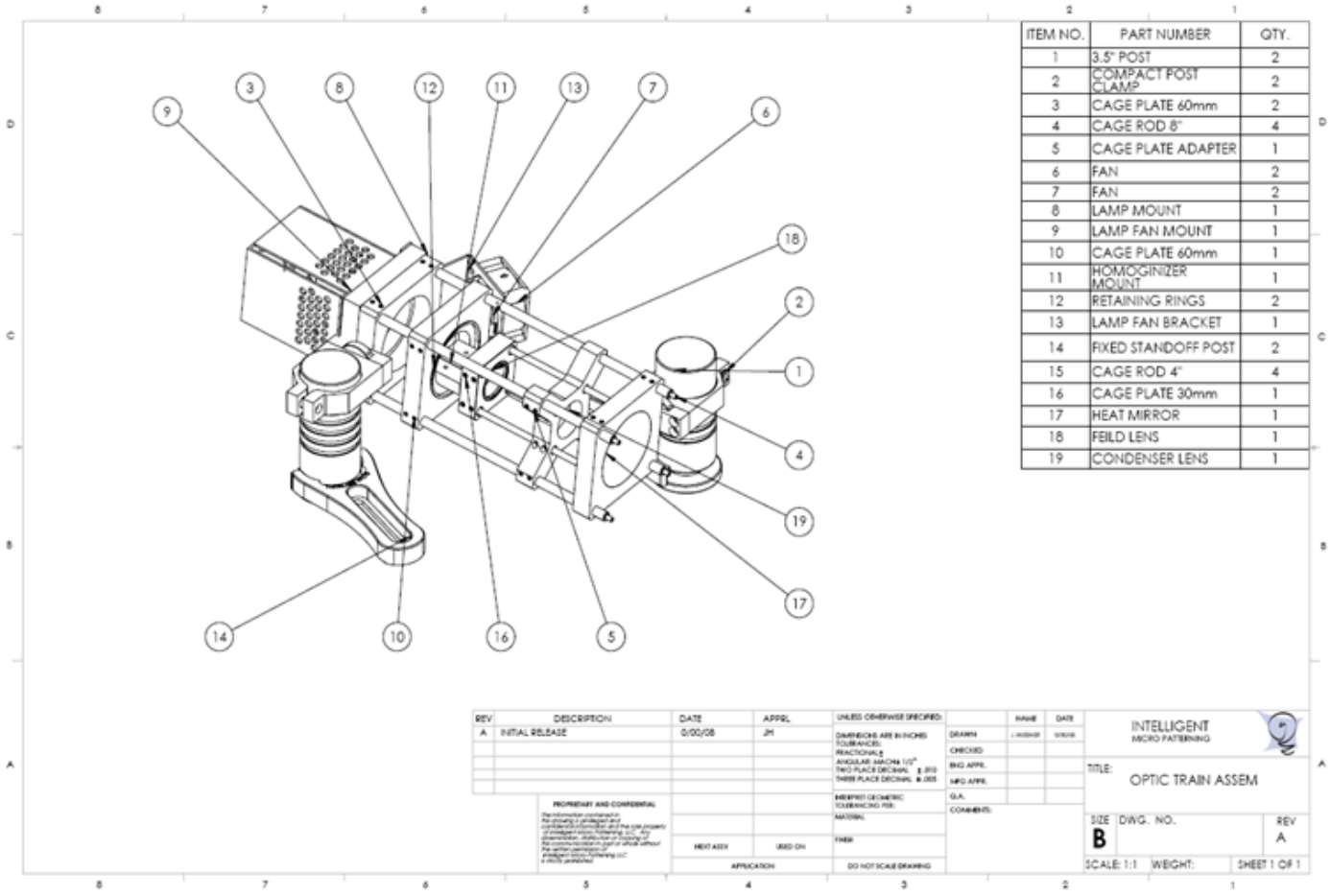


Double-Click On the Image Above to See Wiring Diagrams

6.2.2 Filter Wheel XTREME



6.2.3 Optical Train XTREME



ITEM NO.	PART NUMBER	QTY.
1	3.5" POST	2
2	COMPACT POST CLAMP	2
3	CAGE PLATE 60mm	2
4	CAGE ROD 8"	4
5	CAGE PLATE ADAPTER	1
6	FAN	2
7	FAN	2
8	LAMP MOUNT	1
9	LAMP FAN MOUNT	1
10	CAGE PLATE 60mm	1
11	HOMOGINIZER MOUNT	1
12	RETAINING RINGS	2
13	LAMP FAN BRACKET	1
14	FIXED STANDOFF POST	2
15	CAGE ROD 4"	4
16	CAGE PLATE 30mm	1
17	HEAT MIRROR	1
18	FEILD LENS	1
19	CONDENSER LENS	1

REV	DESCRIPTION	DATE	APPR.
A	INITIAL RELEASE	0/00/08	JH

INTELLIGENT MICRO PATTERNING

TITLE: OPTIC TRAIN ASSEM

SIZE B | DWG. NO. | REV A

SCALE: 1:1 | WEIGHT: | SHEET 1 OF 1

6.2.4 Smart Filter XTREME

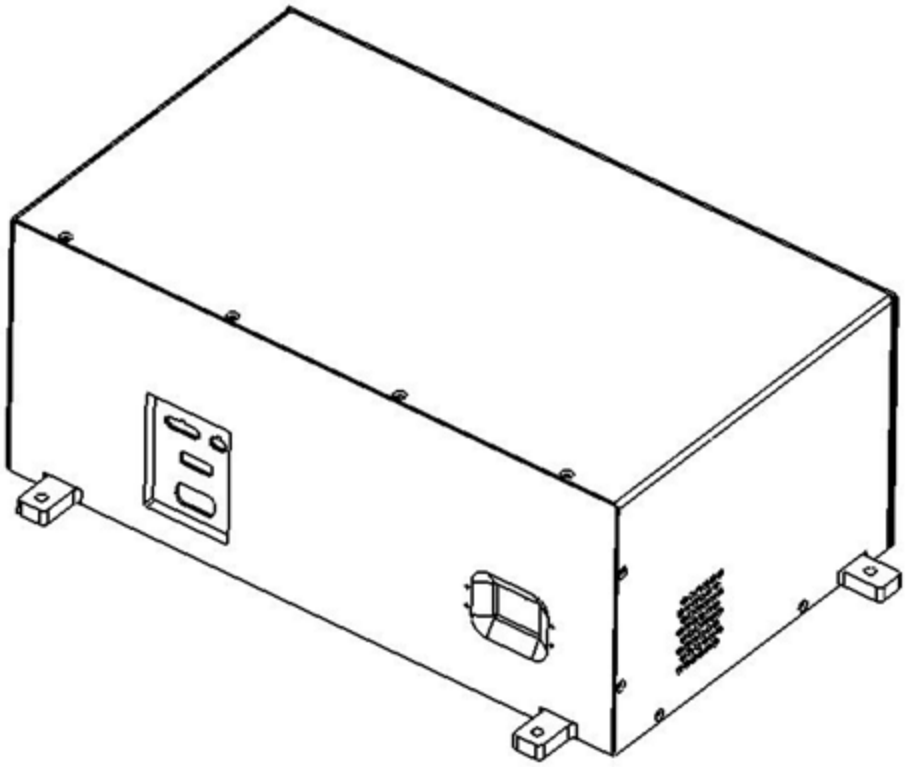


Figure 6.2.1: *Smart Filter*™ Enclosure

Note: The electronics used in the *Smart Filter*™ are proprietary and therefore cannot be shown.

6.2.5 Main Tool XTREME

Under Construction.

INTELLIGENT
MICRO PATTERNING, LLC

Part VII

7 Auto Stage Program Overview

This is a basic overview of all the features and options available to the user of the *Auto Stage*™ program. For specific procedures related to the program please refer to "*Auto Stage*™ Procedures."

7.1 Login Screen & Setup

The first screen that will popup when opening the *Auto Stage*™ program is the login screen (*see Figure 7.1.1*). In addition to limiting access to the tool, the login screen allows the use of different credentials in order to protect certain settings in the program from being changed by an inexperienced user.

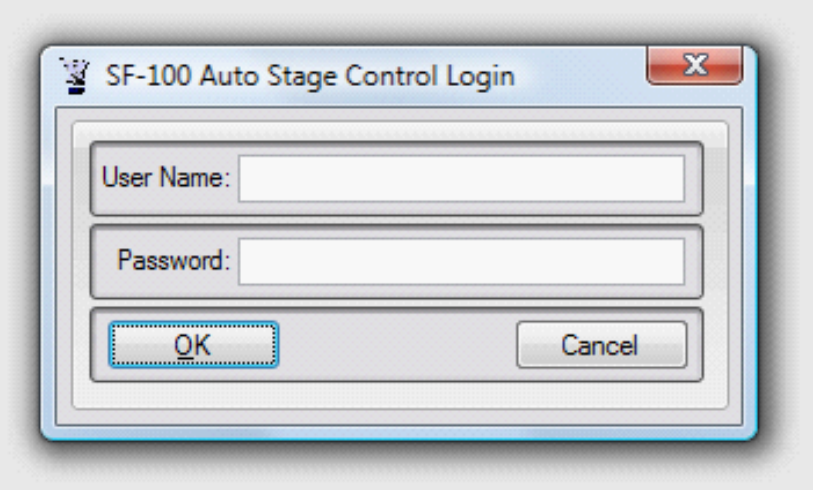


Figure 7.1.1: Login Screen Popup

Users can be added, modified, or deleted from the system by accessing the "Options" drop down key and in the drop-down menu clicking “Add User Accounts” (*see Figure 7.1.2*).

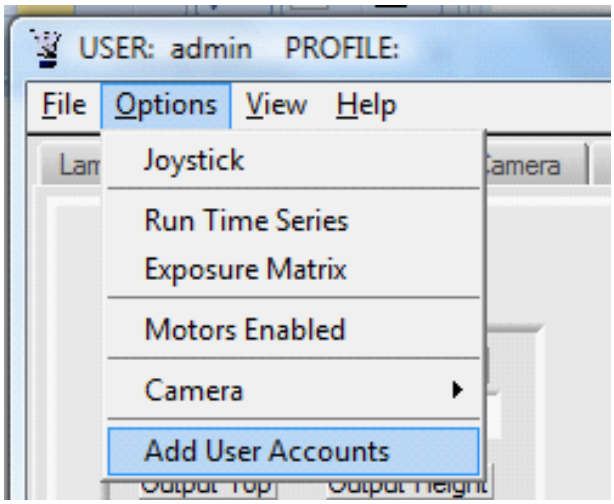


Figure 7.1.2: Add User Accounts (Upper Left Corner of Main Window)

When clicking "Add User Accounts" the following window will pop up (*see Figure 7.1.3*). Click the appropriate box, depending on what you are trying to do.

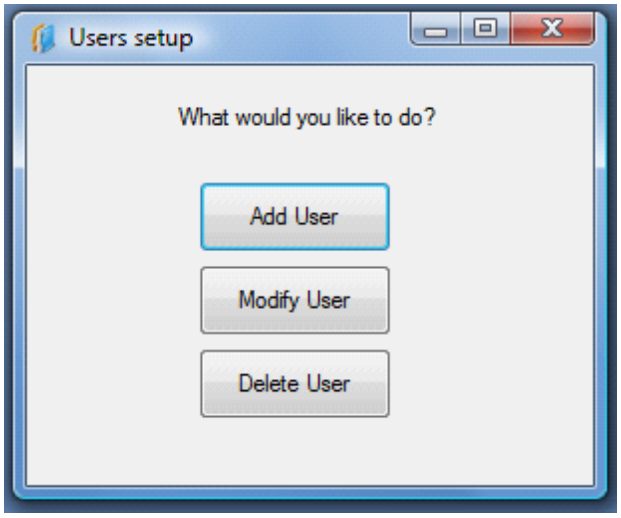


Figure 7.1.3: Users setup box

Add User

A new user can be added by assigning a User Name, password, and confirming the password in the provided space. At the bottom of the box the type of user can be chosen (whether or not he/she will be classified as an administrator). In addition, the user's access to the different program tabs can be limited. A check in the box next to the respective tab will allow the new user access to that tab.

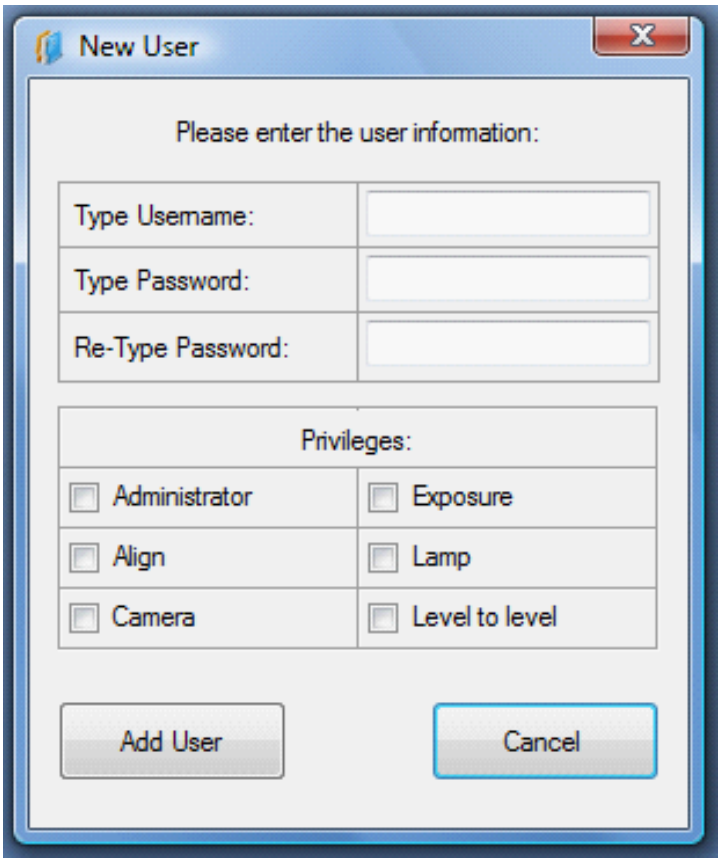


Figure 7.1.4: Add User box

Modify User
This option allows the modification of an existing user account. It allows the user to change all the options available in the "Add User" section for an existing account (*see Figure 7.1.4*). It also allows the modification of passwords and usernames.

Delete User
This option allows the removal of user accounts. Be aware of the fact that you must be logged into an account with administrative privileges to delete other accounts; also, you cannot delete an account that you are currently logged into.

7.2 Lamp Control Tab

A tab is included in the program so the user may access lamp controls, such as: switching on/off, viewing

remaining lamp hours, resetting the lamp timer, and performing diagnostic testing (*see Figure 7.3.1*).

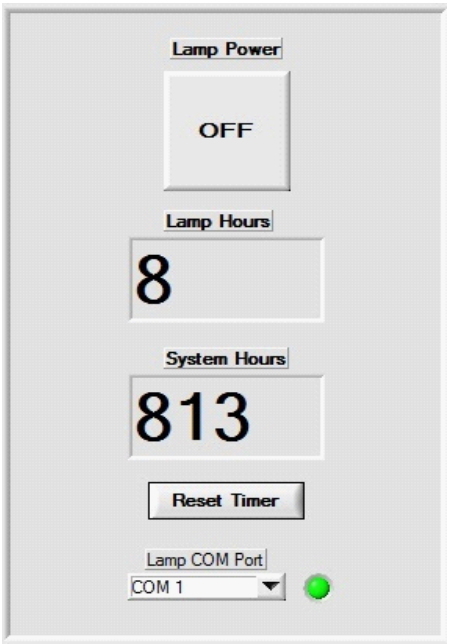


Figure 7.3.1: Lamp Control tab

Lamp COM Port
This port communicates between the PC and the System Lamp. The drop down box will have a list of available COM Ports. Make sure the correct port is selected and the COM Port light will turn green.

Lamp Power Button
The user may use this button to control the power to the lamp. If the lamp is shut off please allow 2 minutes before turning the lamp back on. The program can be closed without turning the lamp off. A prompt will ask, “The lamp is still on do you want to close the program?” If the lamp is left on, when the program is re-opened a prompt will ask, “Is the lamp currently lit?”

System Hours
This indicates the hours the system has been running. The system hours show the overall life of the system with the lamp running.

Lamp Hours
This indicates the total number of lamp hours. You may wish to monitor this and schedule your replacement lamp orders accordingly. When the lamp hours reach 1,000 it is recommended that the lamp be replaced.

Reset Lamp Timer
After the lamp has been replaced, the lamp timer should be reset using this button.

> Note: If you encounter any problems with the system or lamp hours, notify Intelligent Micro Patterning Customer Service for assistance.

7.3 Main Panel

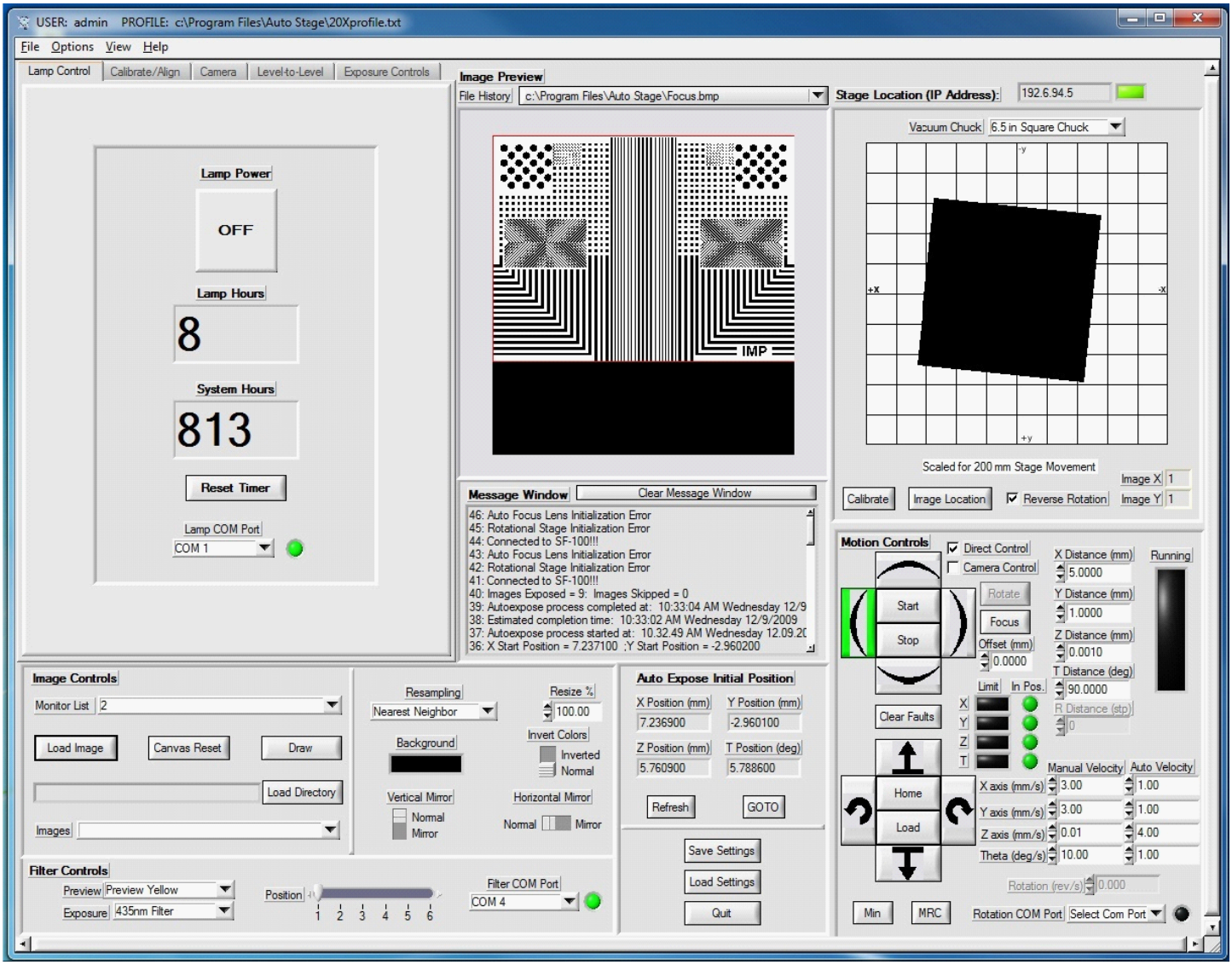


Figure 7.2.1: Main panel of *Auto Stage*™ program

7.3.1 Filter Position

Filter COM Port
The Filter COM Port pull down tab will allow the filter direct communication with the PC. When the correct port has been selected the LED will illuminate green. This lets the user know that communication has been established between the filter wheel and the PC (*see Figure 7.2.1.1*).

Position
Using the slide bar to select a position on the filter will manually turn the filter wheel to the selected position. This is for manual use of the filter only. There are 6 available positions in the filter wheel (typically, the first position is populated by the preview filter and the last position is populated by the 435nm exposure filter, with all other positions being user specific).

Preview
After clicking the pull down tab the available filters will be displayed. The one that has a check by it is the one that is being used for preview only. This will most likely be the yellow filter; this is to prevent UV from hitting the substrate when the user is not doing exposure shots.

Exposure
After clicking the pull down tab, the available filters will be displayed. The filter selected in the drop down is the one that will be used for exposures.

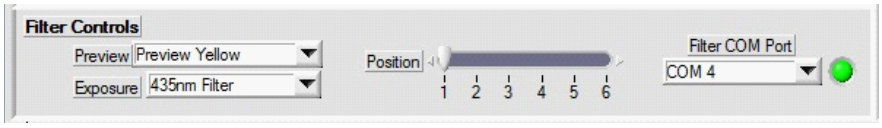


Figure 7.2.1.1: Filter wheel controls

7.3.2 Motion Controls Section

Velocity of Stage Settings (*see Figure 7.2.2.1*)
Changing the Velocity values adjusts the estimated movement speed, as indicated. “Manual velocity” is used when the direct control box is checked and the stage is being manually moved. “Auto Velocity” is used when stage is running automatically.

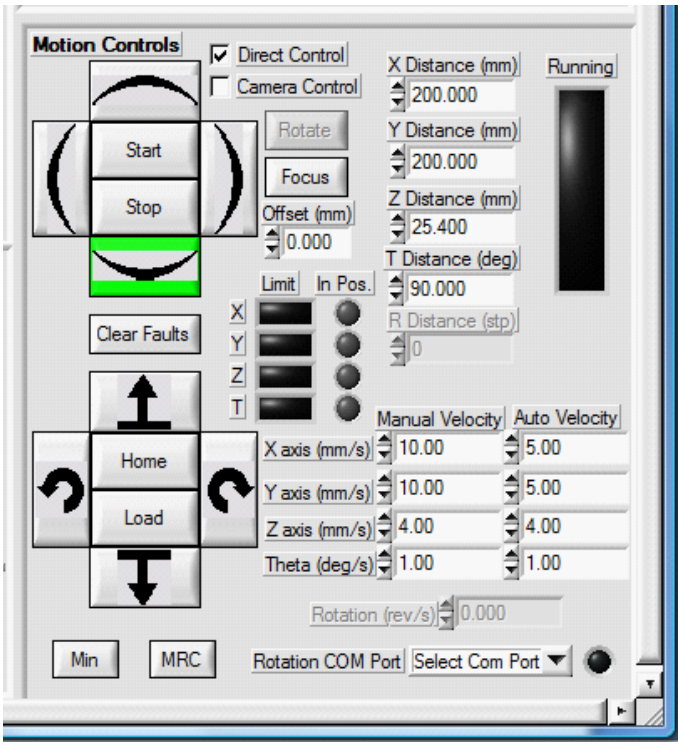


Figure 7.2.2.1: Stage Motion Controls (Located in Bottom Right Corner of Main Window)

Changing the Velocity values directly affects the movement resolution. Faster speeds will make movements more coarse, best for large-feature sized images, that do not require high resolution movements. Slower speeds will make movements finer and more repeatable. Velocity changes are made by highlighting the appropriate box and entering a new value, or by left-clicking the up/down arrows.

> Note: The Velocity can be set from .01 -50 mm/s for X and Y movements. The Z can be set from .01-4 mm/s, and Theta can be set from .01-180 Degrees per second. The high value is the fastest speed the respective axes can move and should only be used for general stage motion, but *not* during an exposure sequence. For exposure sequences you should not exceed 10mm/s on the X and Y.

Movement feedback: Encoders

The encoder values are located in the Calibrate/Align tab (refer to "Encoder Feedback"). The values shown are relative to any starting position (0,0,0,0). Movements Down (Y-axis), Right (X-axis), Vertically (Z-axis), or Clockwise (Theta-axis) will increase the encoders and vice-versa. Encoder errors (limit exceeded, etc.) will add a yellow frame to the window of the affected encoder. Error details will be shown in the error window.

Manual Mode
Indicated by placing a check in the "Direct Control" box located in the "Motion Controls" section. In this mode, direction of the stage is *not* relative to the image but is only relative to the SF-100 unit, and the user has full control of the stage movements.

Stage movement is initiated when a desired direction button is selected, and the Home, Step, or Start/ Stop buttons are left-clicked. How each button affects movement is described below. The top rectangular direction button is for the Y-axis**,** and will set the movement mode of the stage from the Front toward the Back (away from the operator). The bottom Y-axis button sets movement mode opposite of the button described previously. The "Left" (X-axis) button will set the movement mode of the stage along the front plane of the SF-100 to the left. The "Right" (X-axis) button is opposite along the same plane. Z-axis or vertical movement buttons located in the lower set of direction controls will set the movement mode of the stage up (top button) or down (bottom button). It is used solely to focus the exposure images onto the substrate and should be verified and re-adjusted when substrate thickness changes. Movement of this axis is disabled by the "Direct Control" switch.

The theta-axis or rotational movement about the central vertical axis, is shown as right or left turning arrows on the lower set of direction controls. It is also disabled by the "Direct Control" box when a check is not present. Clockwise rotation, as viewed from the top, increases the encoder. Counter-clockwise rotation decreases the encoder. This axis has no limit switches so encoder values should only be used for relative references.

"Camera Mode" is similar to the manual mode ("Direct Control" must be on). This will move the stage in a direction that will make it look as if it is moving correctly, if you are looking at the feed coming from the camera. The stage movement is rotated 90 degrees compared to the button pressed. "Up" will actually move the stage "left", but if you look at the camera feed it will look as if it is moving to the back of the system. Clicking "Left" will actually make the stage move towards the "front" of the system, but looking at the feed from the camera it will look as if it is moving to the left.

Automatic Mode
Is created by un-checking the "Direct Control" check box. Use the "Auto Exposure Setup" button to establish a fully automatic exposure operation. Movement of the stage is *relative to the image* in this mode with the accepted knowledge that the computer image is left-right mirrored onto the stage/ substrate horizontal plane. Semi-Automatic Mode is similar to the Automatic mode ("Direct Control" is off and movement is *image*-relative), but is a state wherein the stage movements are *manually*-initiated by using the direction button combinations.

"Start" and "Stop" are selected, once the direction button is chosen to start and halt continuous movements. The stage will stop after it has moved the number of counts in the "Scroll Range" box corresponding to the direction chosen. This is also one (red) exposure frame amount.

The speed with which the movement proceeds is controlled as described above under "Velocity of Stage Settings". The "Start" and "Stop" physically perform the following: "Up" movement "Start" commands move the stage to the "right" along the front plane of the SF-100; this is toward the top of the

image. “Down” is opposite, to the “left”. The “Right” movement command moves the stage away from the operator, toward the back of the SF-100, which is toward the right side of the image. “Left” command moves the stage toward the operator. “Stop” halts the active movement before it reaches the Scroll Range value, unless it is already stopped.

> Note: If any reduction lens is installed these movements will be rotated 180°. Therefore, “Up” will switch to “Left”, and “Down” will switch to “Right” and so forth.

Keyboard Shortcuts

Keyboard Shortcut for Direction: Shift-key with any of the arrow keys will highlight the corresponding X or Y axis direction button.
Keyboard Shortcut for Movement: Shift + Home will “Start”; Shift + End will “Stop”.

The “Home” Button

The “Home” button resets X, Y, Z and theta axes to their zeroed encoder positions. A prompt will ask the user which axes need to be homed. Select the correct axes and click OK to continue. If the theta is selected a prompt will let the user know the theta is about to rotate, and ask whether or not it is safe to do so (*see Figure 7.2.2.2*). The X and Y axes’ will move to the upper right corner and then back to the center. The Z stage will lower to its minimum position and then return to the user’s desired location assigned to the stage. The theta will rotate until its home position is reached. This task will only need to be performed if the controllers lose power or are turned off.

> Note: Please make sure the stage area is free from obstructions. These can include, but are not limited to: vacuum hoses, optical fibers, and wires.

The “Load” button

Moves the Y axis towards the front of the system to load and unload a substrate. The stage will move at 10mm/s until the Y limit is reached. A prompt will say “Please deposit/remove substrate”, and once the task is completed, click “OK” to go back to its original position.

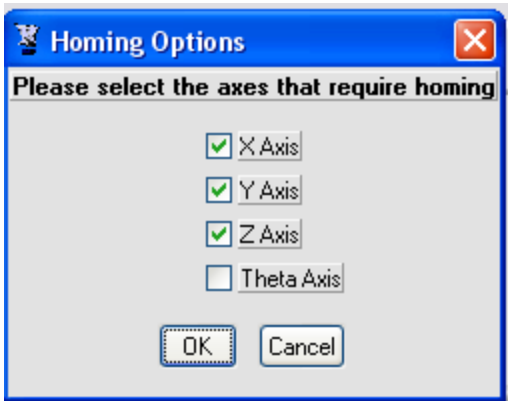


Figure 7.2.2.2: Homing Option

The Autofocus Routine

The user can access and run the autofocus routine by clicking the "Focus" button located on the right side of the X and Y axis selection buttons (*see Figure 7.2.2.1*). After the autofocus routine runs, the stage will be at the optimum height for exposure in the area of the substrate displayed in the camera view. This routine works by setting the stage height, according to the maximum contrast ratio of the projected image as seen by the camera (refer to "Camera Tab").

> Note: For the autofocus to work correctly the stage height must be set so that the projected image can be clearly seen in the camera view. The routine will then fine tune the height.

Focus Offset

This value, located directly under the "Focus" button, is used when an automatic offset from the correct focal height is desired (*see Figure 7.2.2.1*). After setting a value in the box (positive or negative depending on whether the user wants the offset above or below the focus) and clicking the "Focus" button, the program will run an autofocus routine and offset the value found in the routine by the amount in the box.

Min and MRC

These buttons, located in the bottom left quadrant of the "Motion Controls" section, are used to save specific stage positions and return to them. These work independently from the save position feature of the "Auto Expose Initial Position" section. They are very simple to use, the "Min" button saves the current position of all the axes' of the automated stage and the "MRC" button will return the stage to the saved position.

7.3.3 Image Controls

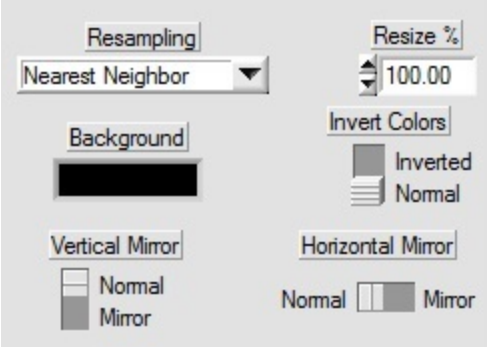


Figure 7.2.3.1: Image Controls box on Main Panel

Invert Colors
This switch performs a "reverse video" on the image as a whole, in other words white becomes black and visa versa. Note that it does not alter the original file, just the loaded image.

Horizontal Mirror
This switch allows a reversal to compensate for the optical left-right mirror presented to the substrate relative to the loaded image. The image will now appear mirrored but the exposure image will match the original file. Again, the switch is changed by left-clicking on it or the desired condition word.

Vertical Mirror
This switch works the same as the Horizontal mirror switch except it alters the up-down perspective, as desired.

Background
This drop down controls the color behind the image. Remember that black is "no exposure" and white is "full exposure". This is especially important if part of the exposure window hangs off of the artwork (as is usually the case when doing a mutliple shot exposure).

7.3.3.1 Scale Control

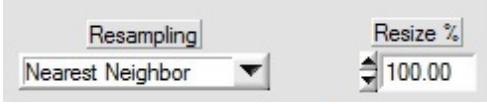


Figure 7.2.3.1.1: Scale settings

Resize %
The scale of the original bitmap can be changed if desired. This may be useful for slight adjustments to small variations of substrates, for example. The percent desired can be chosen for both Width and Height. The values can range from 0 % to 200 %. The default is 100%. The input allows values to two decimal figures and will round off the values if the sizing interferes between two adjacent pixels. When resizing the program also allows the user to choose the desired re-sampling method in a pull down menu beside the scale control.

Resampling
The simplest interpolation method is Nearest Neighbor. Using the Nearest Neighbor algorithm, neighboring pixels are copied into the spaces created when the original pixels are spread out during the resizing process. Although this is the fastest of the three methods, it can result in jagged edges if shapes other than straight lines are being resized.

To reduce the pixilation and step like boundaries produced by using nearest neighbor interpolation, Bilinear interpolation can be used. Bilinear interpolation explores the four points neighboring each pixel enabling an averaged value for the unknown pixels. While the bilinear interpolation process is slower than nearest neighbor interpolation, using bilinear interpolation results in visibly smoother results.

To adjust for the linear interpolation blurring that takes place with bilinear interpolation, bicubic interpolation can be used. Bicubic interpolation improves the quality of the resized image by approximating the brightness function locally using a bicubic polynomial surface. By doing this, the sixteen neighboring points surrounding each pixel are used for interpolation. For bicubic interpolation in the *Auto Stage*™ program, the Catmull-Rom algorithm is used. Although the bicubic interpolation process is the slowest of the three implemented in the *Auto Stage*™ program, it corrects the step-like boundary problem seen with nearest neighbor interpolation, and blurring seen with bilinear interpolation.

7.3.4 Stage Location

The Stage Location in the Stage program helps the user determine the position of the substrate in reference to the stage. A black square in the display window represents the area of the system vacuum chuck “6.5 in Square Chuck” (*see Figure 7.2.4.1*). The pull down menu under "Vacuum Chuck" can be used to choose the appropriate chuck.

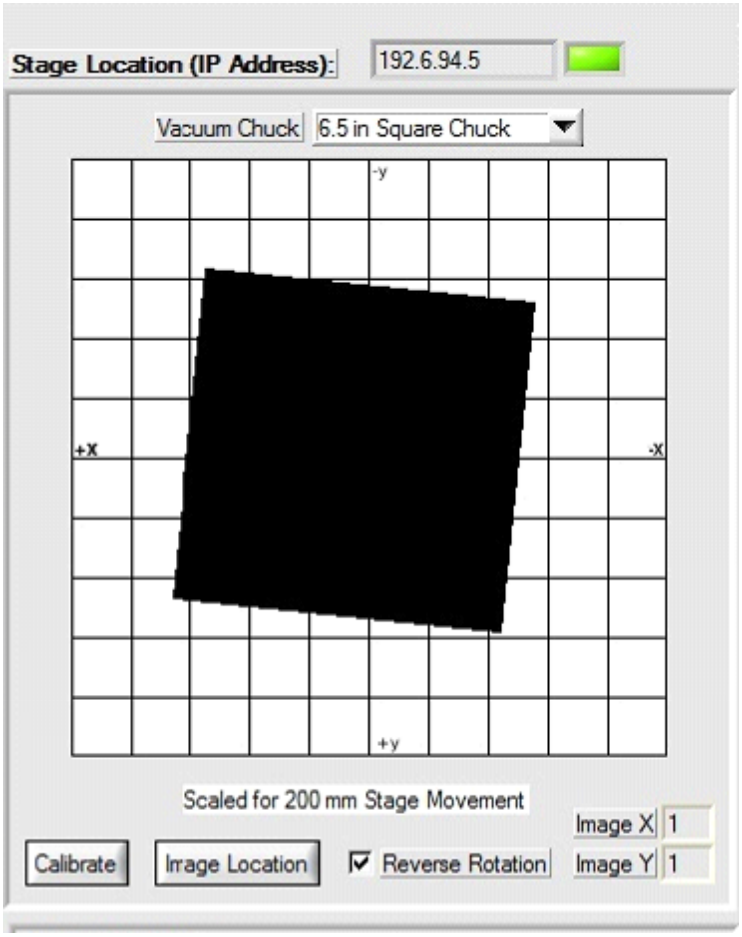


Figure 7.2.4.1: Stage location window

The stage location can be calibrated, but this should have already been set by the factory. The Stage Location should not need to be calibrated unless the stage is moved. if it is neccessary to calibrate the stage location select “Calibrate”, the stage will home to a 0, 0 position for the X, and Y stages. Once the stage is in the home position a prompt will pop up asking the user to “Center the stage under the projected image and click Image Location”. Using the "Motion Controls" move the stage until the center of the Substrate Holder is directly under the projected image. Select “Image Location” and a red box will be located at the center of the black Substrate Holder in the display window. The Stage Location window will now show an approximated location of the exposure window on the substrate.

7.3.5 Image Preview

The image preview window (*see Figure 7.2.5.1*) shows what is currently being displayed on the Digital Micro-Mirror Device (DMD). Whatever is inside the red box is displayed on the DMD. This window can also be used to manually move the DMD display frame (indicated by the red box). The user can manually move the displayed artwork by left-clicking anywhere inside the preview window, this will highlight the preview window in green. After the window is highlighted in green the user can simply use the arrow keys on the keyboard to move the frame. For more information regarding the applications of this feature refer to "Manual Exposure Frame Manipulation".

> Note: The exposure frame is stationary in the window, the artwork is actually what is moving. Therefore, when the user presses the left arrow key, the artwork will move left, which makes the exposure frame seem as though it is moving right.

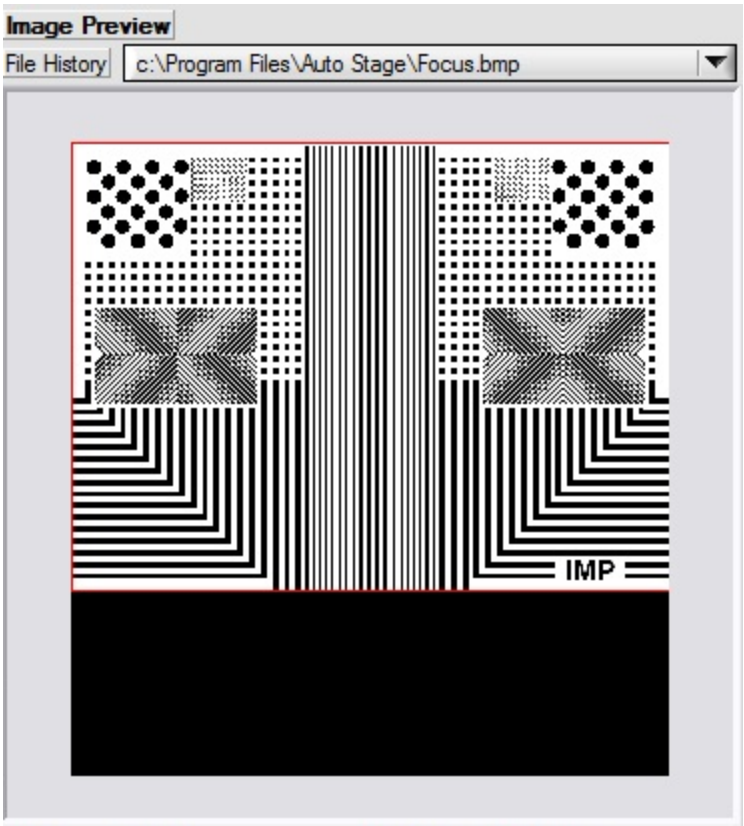


Figure 7.2.5.1: Image Preview Window

7.3.6 Auto Expose Initial Position

This small section, located on the main panel, is useful for saving a position and returning to it at a later time (*see Figure 7.2.6.1*). By pressing the "Refresh" button the various axis fields will be populated with the current values. Then by clicking the "GO TO" button, the stage will return to whatever values are currently saved in the axis fields.

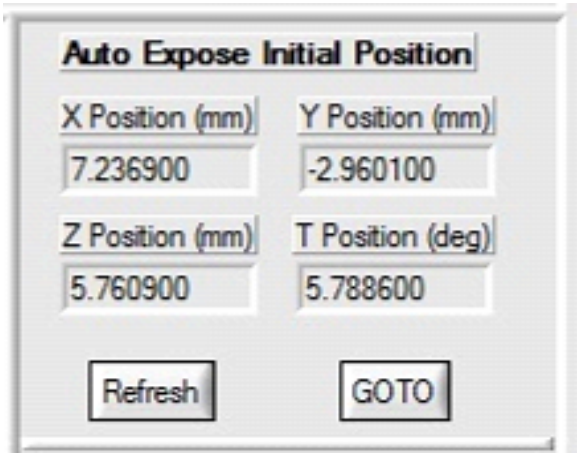


Figure 7.2.6.1: Auto Expose Initial Position on Main Panel

7.4 Calibrate/Align Tab

The Calibrate/Align tab (*see Figure 7.4.1*) is primarily used for setup and calibration. Each section of this tab will be discussed in detail in the upcoming sections.

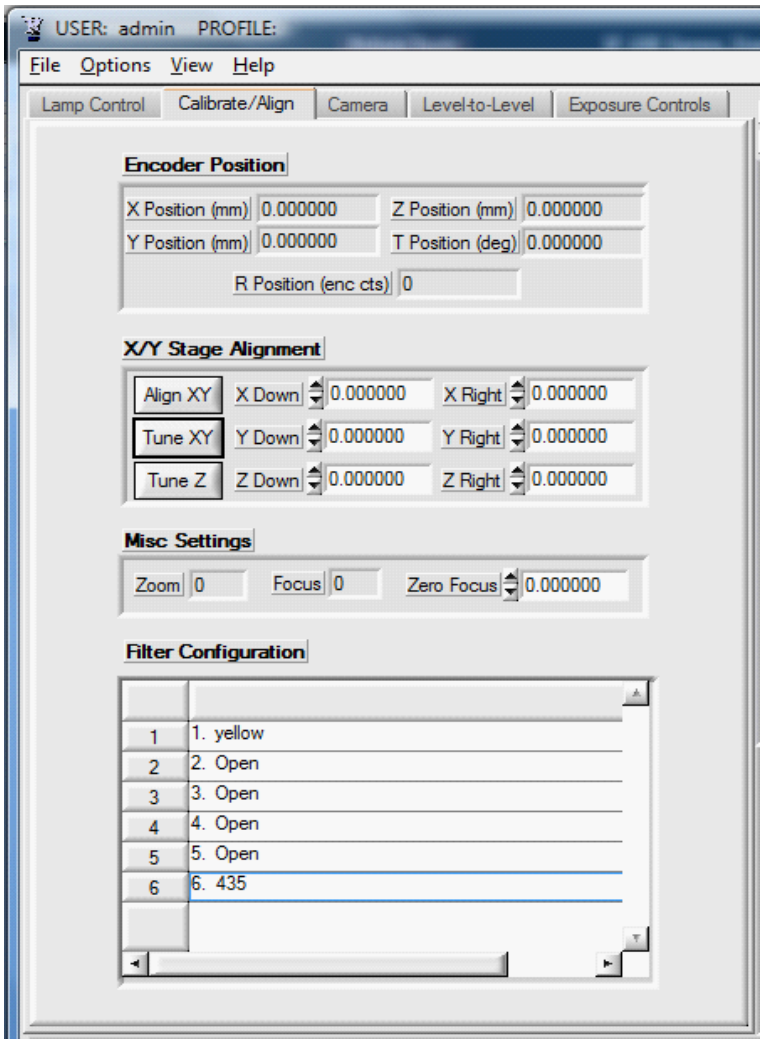


Figure 7.4.1: Calibrate/Align Tab

7.4.1 Encoder Feedback

Located under the “Calibrate/Align” tab are the Encoder values for the servo based stage. The values are relative to the cumulative angular rotation of the stage motors themselves (*see Figure 7.4.1.1*). Specific error details will be shown in the Message Window. If position feedback cannot be read by the program it will be treated as a fault in the limit, the limit light will illuminate yellow. If the stage is at its limits this problem can be fixed by selecting “Clear Faults”, otherwise this will be corrected the next time the encoders are updated.

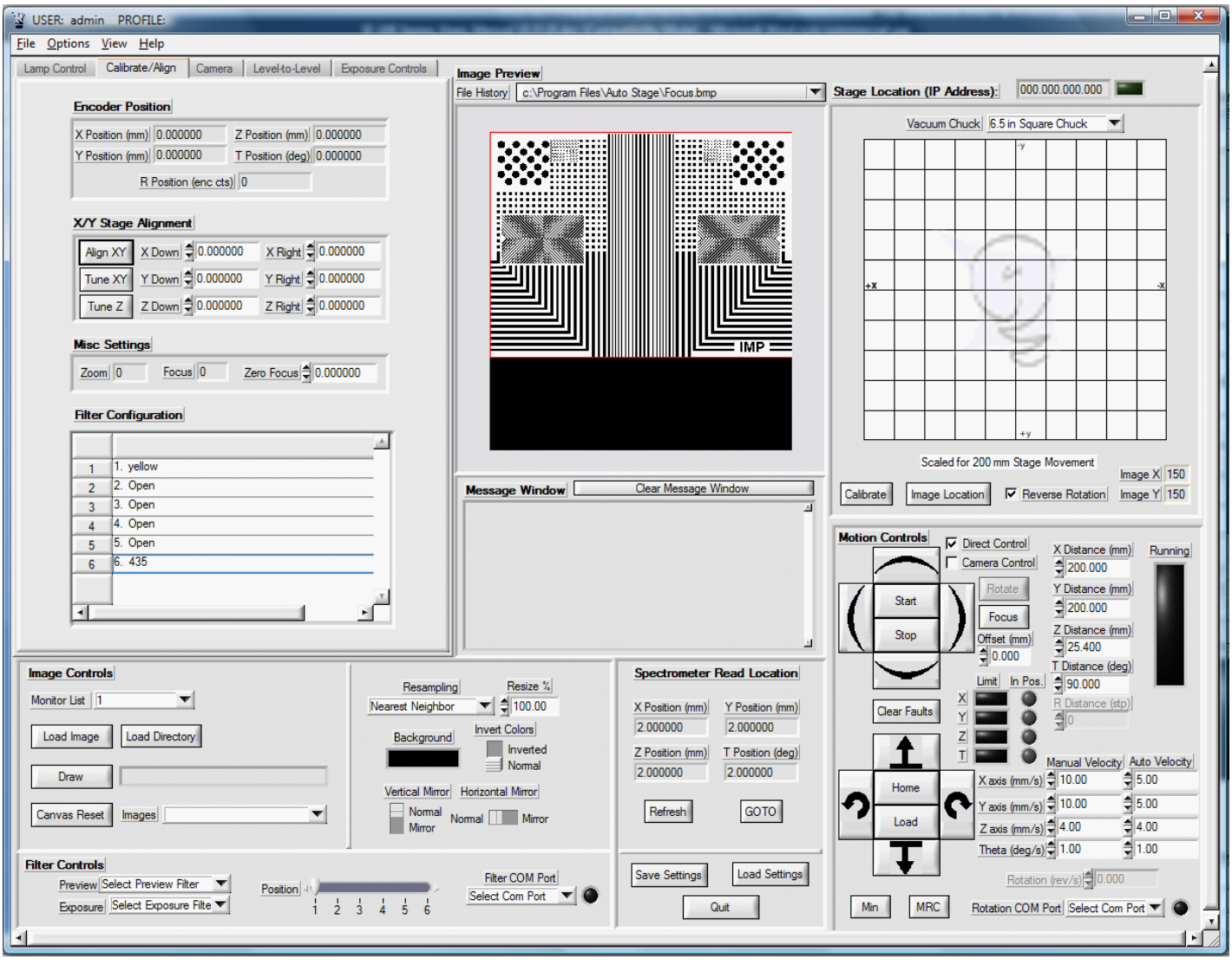


Figure 7.4.1.1: Encoder positions located under the Calibrate/Align tab

7.4.2 Filter Configuration

The filter configuration seen below is used to indicate the name and location of the filters on the filter wheel. There are 6 available slots for filters to be installed on the filter wheel. When a filter has been installed it can be given a name for later selection of the filter that is to be used. This is done by double clicking on the selected space under the filter configuration. Type in the name of the filter and press the enter key (*see Figure 7.4.2.1*).

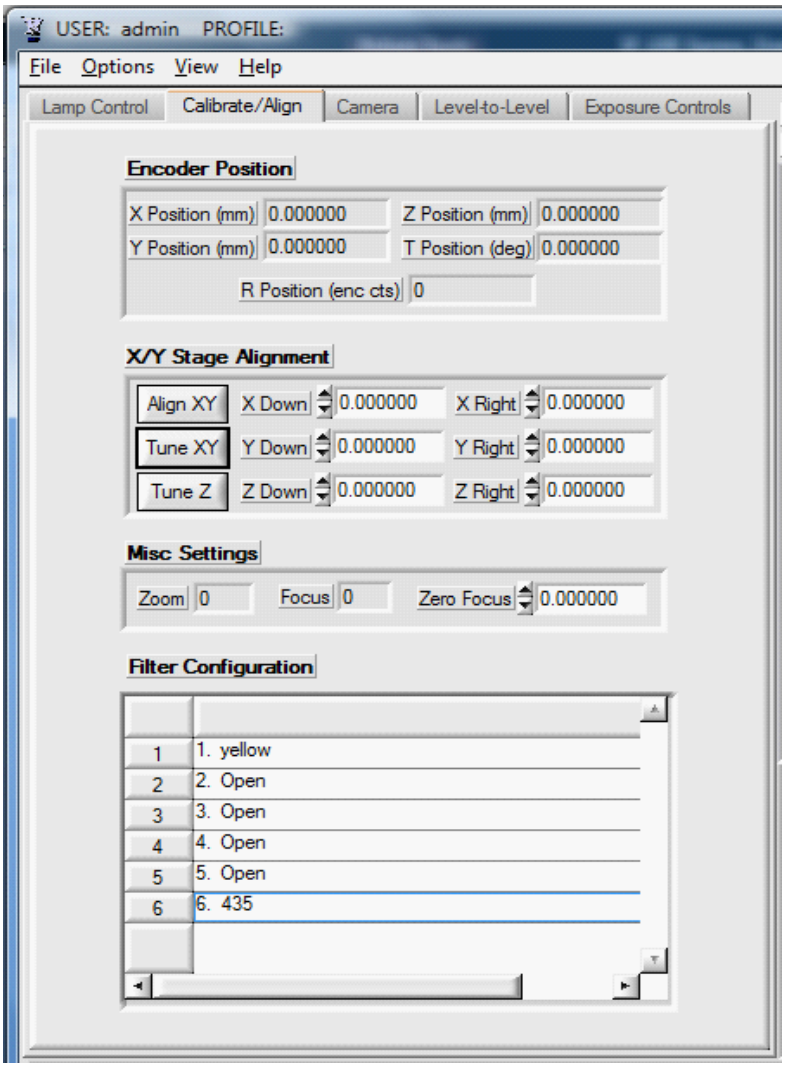


Figure 7.4.2.1: Filter Configuration input table

7.4.3 X/Y Stage Alignment

The Align/Tune section in the calibrate/align tab is for synchronization of the stage to the rest of the tool (since the stage is a standalone unit and is not directly attached to the tool). These functions need only be performed under specific circumstances and will not be used in normal day-to-day operation. For instructions on how to use the tools provided in this section and specific instances when it is advisable to run them, please refer to "Align XY" or "Tune XY" sections.

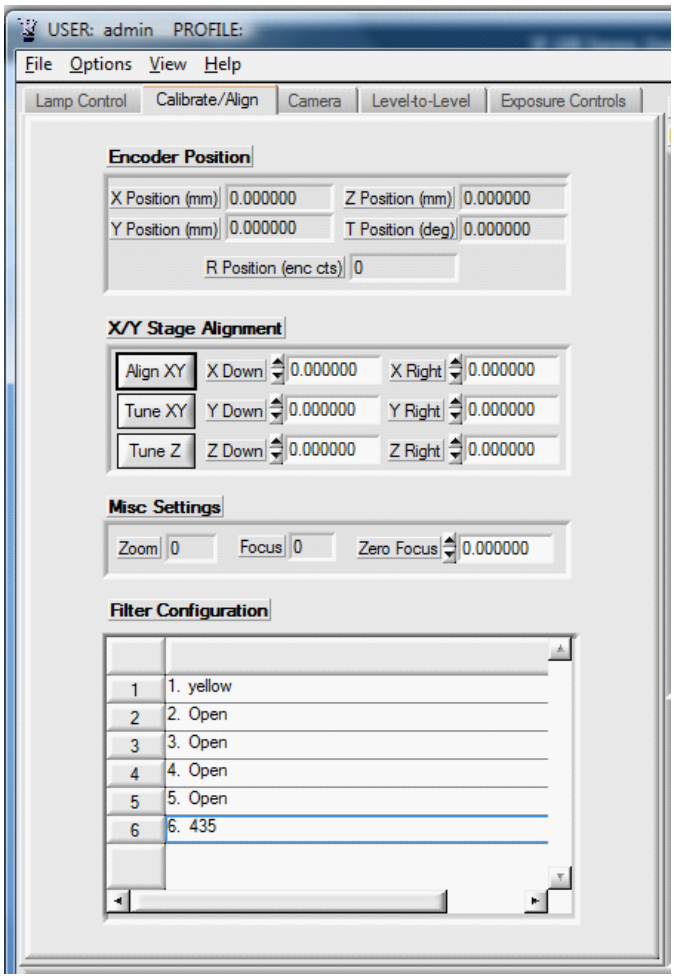


Figure 7.4.3.1: Align/Tune option in Calibrate/Align Tab

7.4.4 Tune Z

The "Tune Z" function in the "Calibrate/Align Tab" has been replaced by the "Linear Height Correction" option in the Auto Expose setup window. It is left in the program for debugging and IMP Engineering use only and should not be used by the end user.

7.5 Camera Tab

To view the image through the camera using the *Auto Stage*™ program, click the "Camera" tab (*see Figure 7.5.1*). The camera is an essential part of the SF-100 unit. It is used for the autofocus routine (as well as manual focus), Level-to-Level alignment (both manual and automatic), calibration/alignment of the tool, and viewing of the projected image and/or the surface of the substrate.

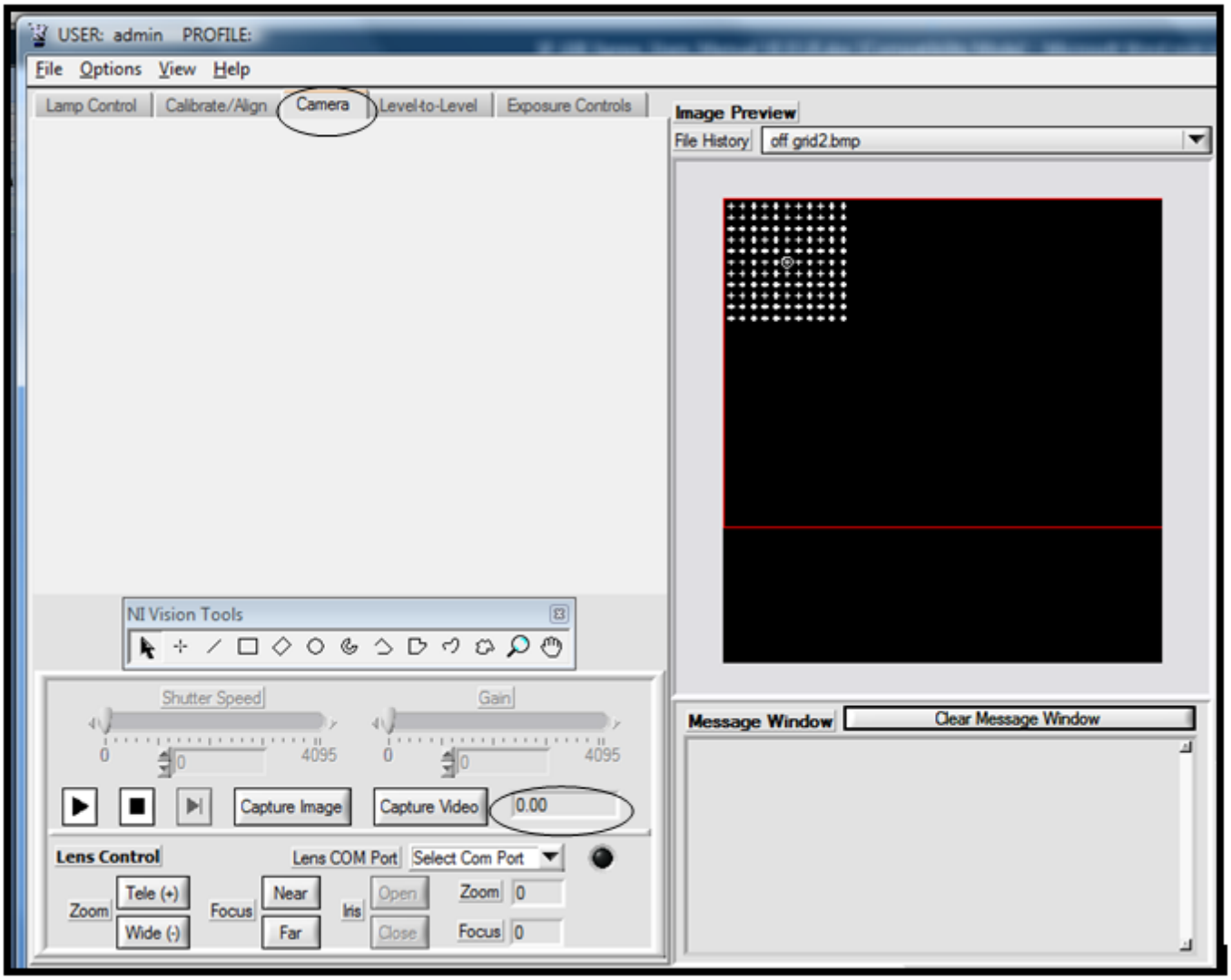


Figure 7.5.1: Camera tab on software interface

View Mode

The view mode of the camera refers to the resolution and frames per second used to capture and display in the camera tab. There are several view modes, however the ideal mode to use is 1280 x 960

@ 7.5 frames per second (mono8).This can be set by clicking on “Options”, then “Camera”.

Features
To get an image that is crisp and sharp, you will need to manipulate one or all of the following settings: Gain and/or Shutter Speed (which controls the aperture). Both of these settings must be set before the image is focused.

“Capture Image” and “Capture Video” will capture the camera view window as a “.jpg” file or an “.avi” file. The "Capture Video" button will continue to record the video, after it is depressed and the user selects the save location, until the user presses the stop button.

The Stage can be moved and the camera can be viewed simultaneously by adjusting the Z- height. Press the play button to view the image. Once the image is focused press the stop button this will allow the image to be captured.

The contrast value (beside the “Capture Video” button in *Figure 7.5.1*) can be used to determine when the image is in focus, the higher the value the better the focus. To get the contrast value, simply press the stop button and then press the "Next Frame" button that is between stop and "Capture Image" buttons. The program will then analyze the displayed image and display the contrast value.

7.6 Level-to-Level Tab

The program has the ability to realign a previously exposed substrate for additional patterning. A minimum of three alignment marks are required on the substrate and bitmap file (for projected image) to accomplish this re-alignment (*see Figure 7.6.1*). There are two different modes to accomplish this, manual and automatic. Although, please note that even in automatic mode the user is still required for certain inputs and initial setup. Please refer to the "Level-to-Level Alignment" section for details on how to perform a manual and/or automatic alignment.

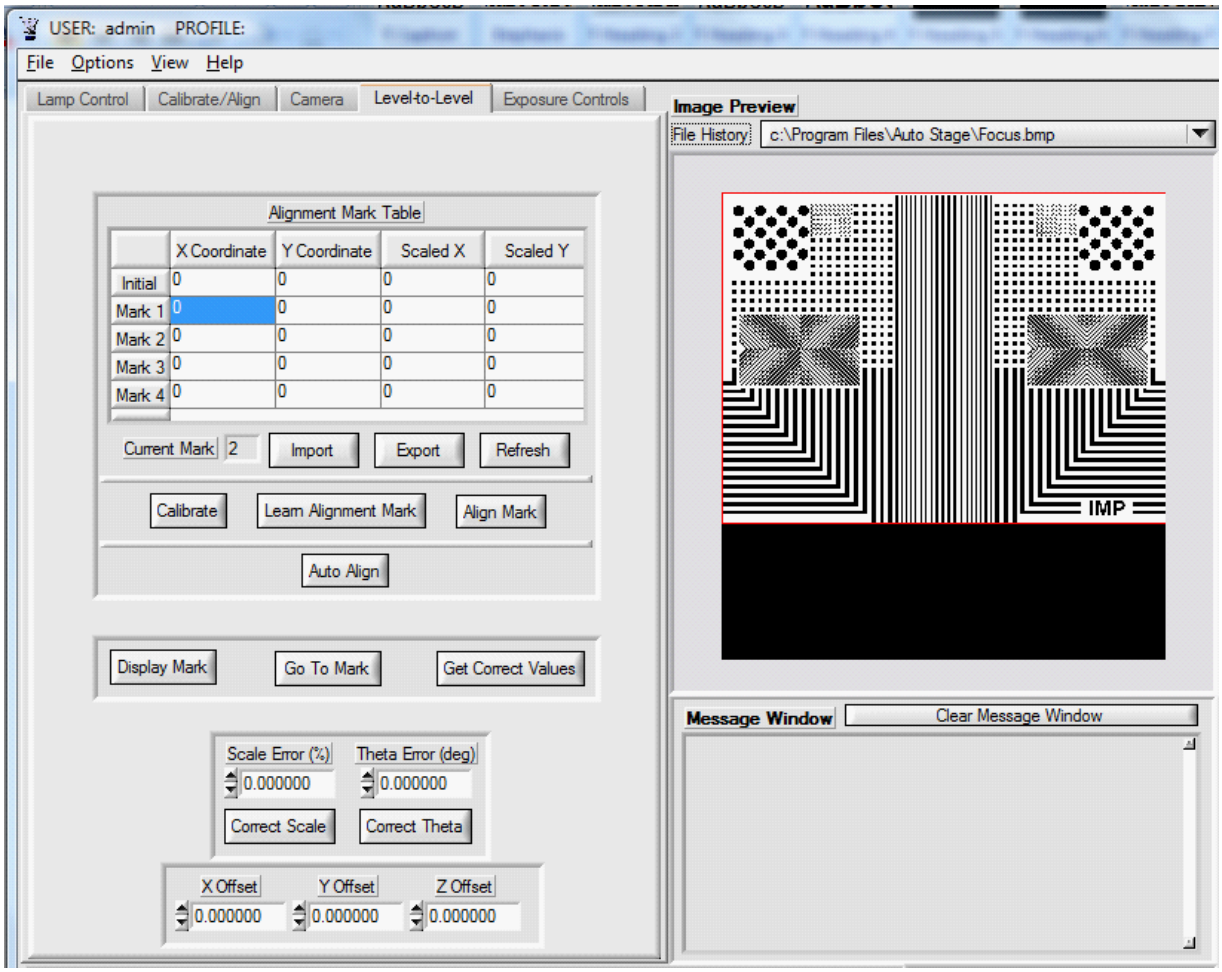


Figure 7.6.1: Level-to-Level tab inside stage program

7.7 Exposure Controls Tab

The Exposure Controls Tab is one of the most important tabs in the program. It is essential for doing any type of exposure. As can be seen in the figure below, there are several different sections relating to the exposure and/or exposure image/artwork. The following sections will explain each section in detail. For specific instructions on the use of the tab please refer to the "Substrate Exposure" section.

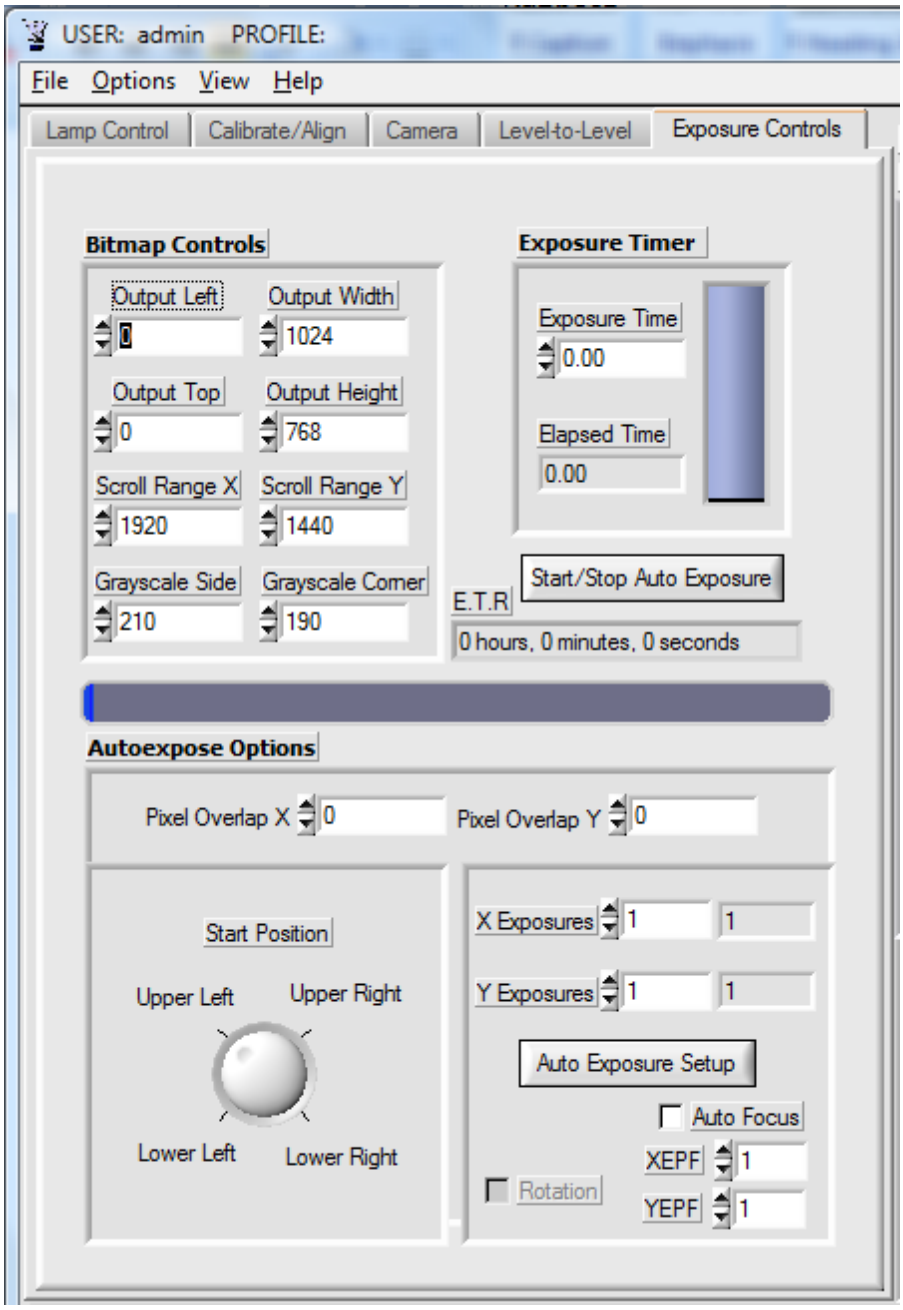


Figure 7.7.1: Exposure Controls Tab

7.7.1 Auto Exposure Options

Pixel Overlap in X and Y allows the user to set a specific number of pixels that will be double exposed

(for an explanation of how these sections do not become overexposed refer to "Bitmap Controls", specifically the section on "Grayscale Side" and "Grayscale Corner"). These values will automatically be entered based on existing Output and Scroll values but can easily be changed here by entering a value directly or by clicking on the up or down arrows.

The “X Exposures” and “Y Exposures” boxes contain the number of exposures in each direction performed by a multiple exposure sequence. The numbers can be manually set by entering the numbers directly or clicking on the up/down arrows. They are also set by clicking the “Auto Exposure Setup” button, which is explained below.

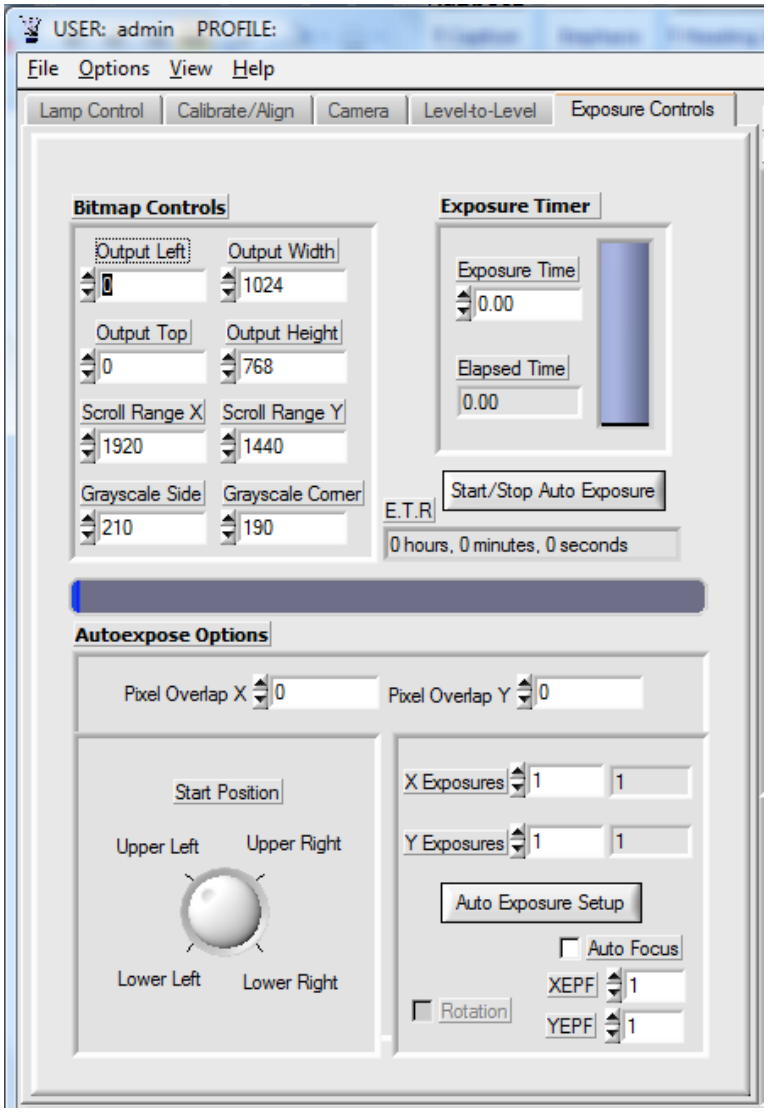


Figure 7.7.1.1: Exposure Controls Tab

The Start Position rotating dial pointer selects the starting corner of the image for an Auto Exposure sequence. If there is only one exposure, the dial has no effect. The dimple is moved by holding down the

left mouse button with the pointer over the dial and moving the pointer in a circular fashion to rotate the dial. The mouse pointer may start at any position on the dial. Automatic sequences start in extreme corners, according to the setting of the “Start Position dial”, and move across the image in the X-direction. At the end of the first row of exposures, the sequence will move one row in the Y-direction (up or down) for the next exposure and then continue in the opposite X-direction. This sequence continues in a serpentine fashion until all the exposures in a sequence are complete. The serpentine pattern optimizes movement time for the sequences.

An auto focus routine can be performed during an auto exposure. If the substrate is not level or needs to be re-focused after a certain amount of exposures check the “Auto Focus box”, and insert the EPF (exposures per focus for the X and Y directions). For example, assume the user checks the box and chooses "3" for the X axis and "2" for the Y axis. On the X axis the program will autofocus on the first shot, then it will shoot two exposures without autofocusing, then on the fourth exposure it will autofocus again. For the Y axis, it will autofocus on the first shot in the first row (still autofocusing according to the X axis setting), then after shooting the first and second row it will autofocus again on the first shot in the third row.

“Auto Exposure Setup**”** is selected when all choices of Auto Exposure are set as desired. The stage will move as directed, all data boxes will be populated with appropriate values, and the image and exposure frame will be adjusted. “Auto Exposure Setup” will need to be selected prior to each Auto Exposure, in order to reset the starting point. After selecting “Auto Exposure Setup**”** substrate placement should be verified for the last time.

“Start/Stop Auto Exposure” can now be selected to run the image exposure sequence. For an additional exposure sequence of another substrate using the same image, the “Auto Exposure Setup” button will need to be selected again to reset the system to the Start Position. Immediately aborting an Auto Exposure sequence requires clicking the “Start/Stop Auto Exposure” button. The current exposure will finish, the stages will move to the next exposure location and then all action will stop. If the user wishes to continue the sequence after stopping refer to "Restarting a Halted Auto Expose Sequence".

7.7.1.1 Start/Stop Auto Exposure Options

After clicking the "Start/Stop Auto Exposure" button there will be a window that appears which gives the user various options relating to the exposure. This window can be seen in *Figure 7.7.1.1.1.* There are four main options available.

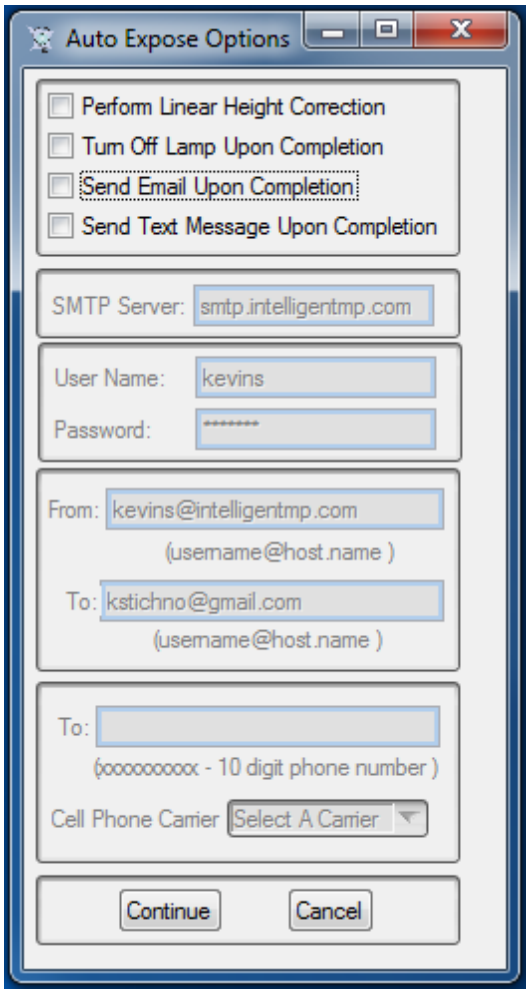


Figure 7.7.1.1.1: Options Window

Linear Height Correction

This option controls whether or not the program will perform corrections for variations in the height of the substrate and/or the thickness of the resist. Upon selection of this option (and after pressing the "Continue" button) the program will move the stage to the location that three corners of the artwork will expose on. It will then perform an autofocus routine at these three locations on the substrate. Finally, it will interpolate corrective height values for all the individual exposures that make up the full exposure area.

> Note: This option is only useful for artwork that is made up of multiple exposures. It is not useful for single exposure artwork because the height is already set correctly by using the Autofocus routine (refer to "Motion Controls").

Turn off Lamp After Completion

This option is self-explanatory. When this option is checked the lamp will be automatically turned off by the program upon completion of the exposure sequence.

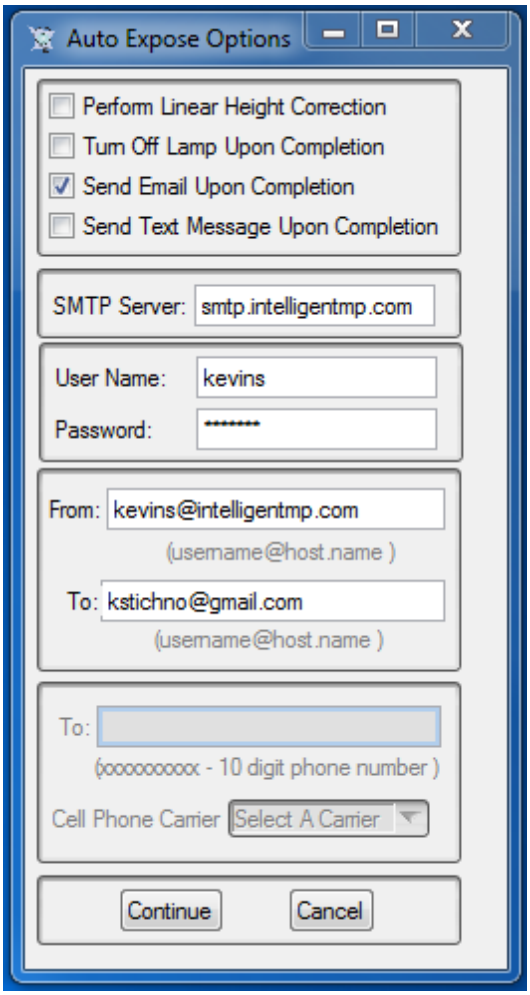


Figure 7.7.1.1.2: Window showing email option

Send Email Upon Completion

This option is useful for lengthy exposures. Assuming the associated fields (SMTP server with username/password) are correctly filled in, the program will send an email to the specified address after completion of the exposure (*see Figure 7.7.1.1.2*). Please speak to your IT technician regarding the SMTP settings.

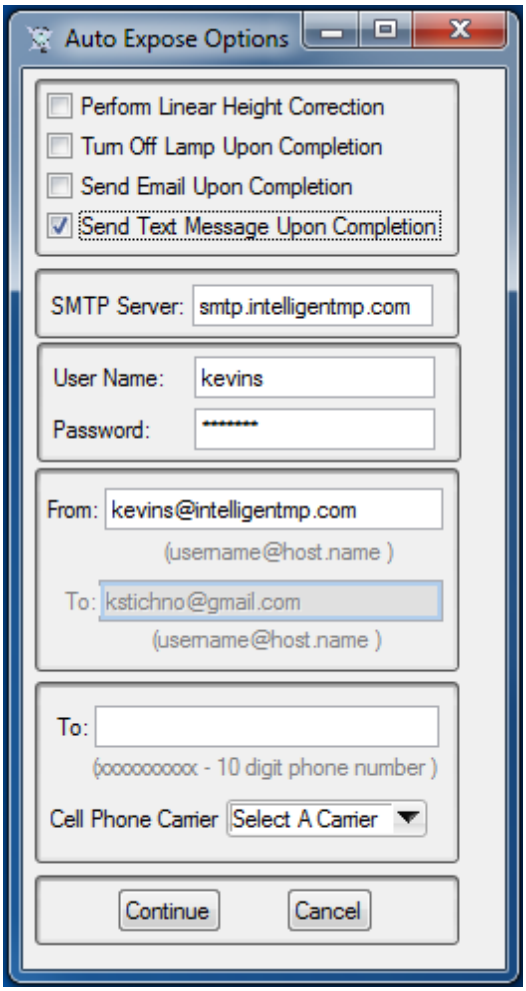


Figure 7.7.1.1.3: Window showing text message option

Send Text Message Upon Completion

When selected, this option will cause the program to automatically send a text message to the specified phone number upon completion of the exposure (*see Figure 7.7.1.1.3*). It sends the text using the same SMTP information that must be used to send an email. It is important that the user select the appropriate Cell Phone Carrier associated with the phone number, in order for the text to be properly formatted.

> Note: Not all Cell Phone Carriers are supported. This feature is only available to customers located within the United States and/or customers who have a US cell phone number.

7.7.2 Bitmap Controls

Figure 7.7.2.1: Bitmap Controls

Output Left
The relative left-side X-axis starting point of the image that will be presented onto the substrate by the *Smart Filter*™ output. It is usually "0" but may be any positive number <1024. Values larger than zero will reduce the maximum width (1024 pixels) of the exposure area.

Output Width
Directly controls the size of the Digital Micro-Mirror Display (DMD) along the X axis. It may be any positive number but must be larger than "0" to have an effective exposure image. The sum of the "Left" and "Width" numbers must be less than 1024. Any excessive area beyond that amount will not be part of the *Smart Filter*™ exposure output.

Output Top
The relative upper-side Y axis starting point of the image that will be presented onto the substrate by the *Smart Filter*™ output. It is usually "0" but may be any positive number <768. Values larger than zero will reduce the maximum height (768 pixels) of the exposure area.

Output Height
Directly controls the size of the DMD along the Y axis. It may be any positive number but must be larger than "0" to have an effective exposure image. The sum of the "Top" and "Height" numbers must be less than 768. Any excessive area beyond that amount will not be part of the *Smart Filter*™ exposure output.

Figure 7.7.2.2 shows the maximum output width and height as they relate to the DMD. Output width and height can also be seen in comparison to the artwork in the "Image Preview" window (where the DMD is represented by a red square). An example of how all the above settings are related can be seen in *Figure 7.7.2.3*. The large black square in *Figure 7.7.2.3* represents the full area of the DMD. The small red square in the upper left hand corner represents the area of the DMD that would be active if the

"Output Width" and "Output Height" were both set to 100 pixels. When doing window sizes that are smaller than the full DMD display, it is advisable to position the active area in the center of the DMD. The "Output Left" and "Output Top" settings allow the user to center the active area. To get these values, use the following formulas:

(1024 - Output Width)/2 = Output Left
(768 - Output Height)/2 = Output Top

So, in our example these values would be equal to:

(1024 - 100)/2 = 462
(768 - 100)/2 = 334

After inputting these values into the "Output Left" and "Output Height" boxes we would get an active area on the DMD that is in the exact center of the full display (see Figure 3).

> Note: This method of reducing and centering the DMD display can be used to achieve additional quality in exposures that require it. Because the DMD is square and the optics are round, there is a very small edge distortion that occurs. For instance, it can occur when approaching the minimum feature size of the tool, if these features occur near the outer edges or corners of the exposure window.

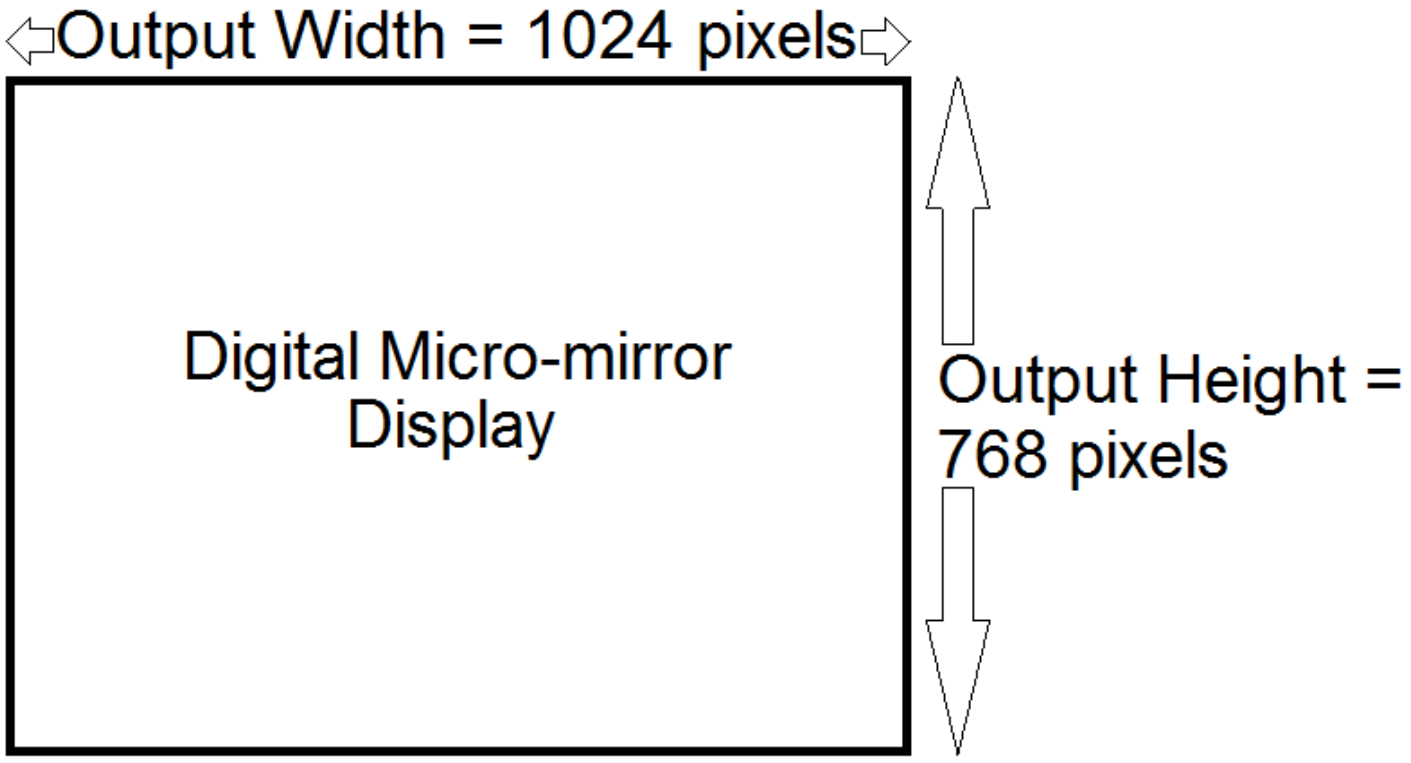


Figure 7.7.2.2: Representation of the relationship between Output Width/Height and DMD

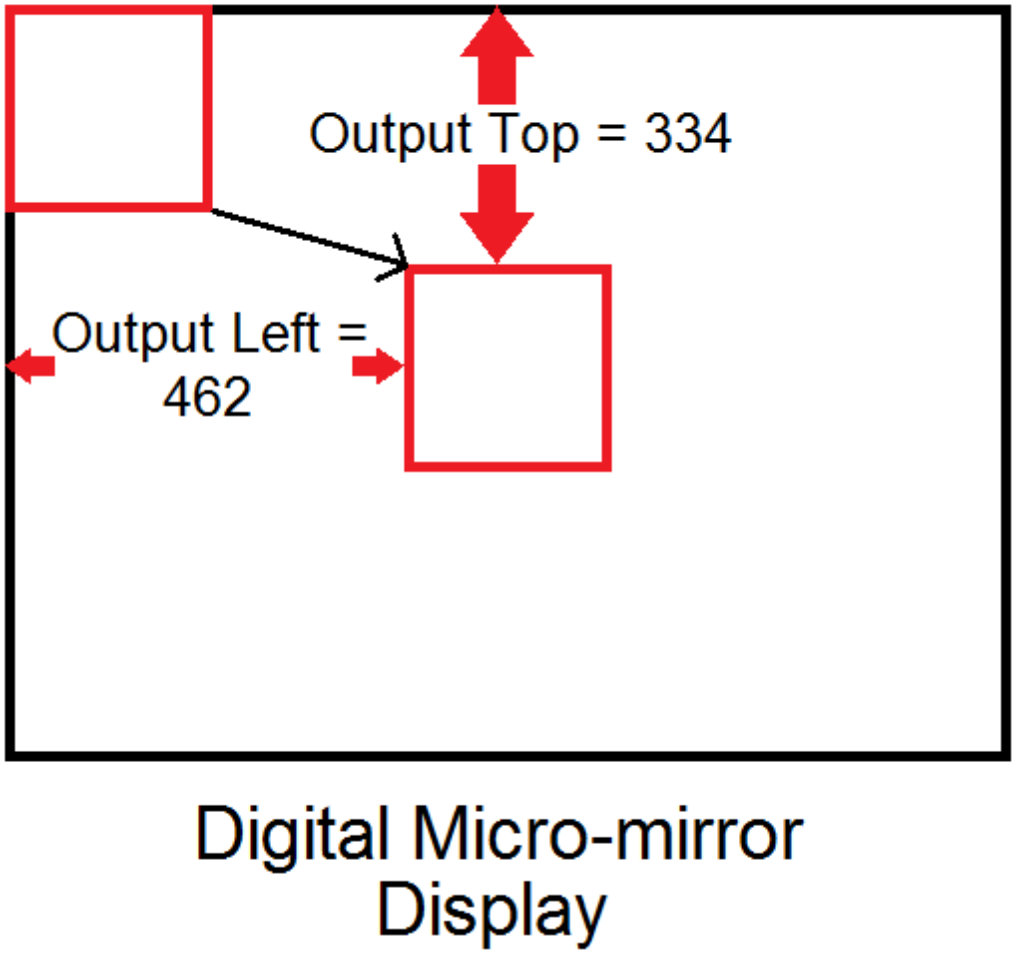


Figure 7.7.2.3: Representation of the relationship between Output Top/Left and the DMD

Scroll Range X
Refers to the horizontal movement of the exposure frame, relative to the image and last frame location, which the auto-exposure uses for subsequent exposures. This can be seen by clicking in the image preview window and using the arrow keys on the keyboard to toggle between the frames.

Scroll Range Y
The vertical equivalent of the “X” scroll range described above.

Overlap of adjacent exposure frames is controlled by the arithmetic differences of the Output Width or Height to the Scroll Ranges of X or Y, respectively. If overlap is desired, then the Scroll values should be less by the amount of overlap desired. If overlap is NOT desired, then the Scroll values should match

(not recommended) or be larger than the corresponding output values (if exposures are adjacent to one another).
For multiple exposures of the same small image, Scroll values can be set more than output values as is needed.

Canvas Reset Button
Located at the bottom of the “Image Controls” section will make “Output Left” and “Top” boxes read zero (0). It will also make “Output Width” and “Height” boxes read the maximum that the available Full Screen (Monitor “2”, “Draw”) has available. This is *normally* 1024 and 768, respectively but may be reduced if special “Always-on-top” program bars (task bars) occupy portions of the screen. “Scroll Range X” and “Y” boxes will also be reset to match the “Output Width” and “Height” boxes, respectively at maximum screen values.

Grayscale

When exposing more than one segment of a larger image, Grayscale options ensure that exposures of adjacent areas are handled without lines or gaps in adjacent exposures.

"Grayscale Side" controls the degree of exposure within the overlap on the top and sides of individual exposure windows. Value varies with several variables but a “200” value is common starting point.

"Grayscale Corner" controls degree of exposure that occurs when the corners of four exposure windows overlap. Value varies with several variables but a “180” value is common starting point.

Grayscale values represent graphic scale levels of grayscale, not exposure percentages or relative time. “0” = Fully black or no exposure and “255” = Fully white or full exposure. Successful exposure with any given set of variables with a specific process requires experimentation to determine optimum values and margins of error.

7.7.3 Exposure Timer

This section, although small, is fundamental to the exposure process. It controls the amount of light energy that the photo-resist is subjected to. The light energy or exposure energy is controlled using a timer that is hundredths of seconds capable, if the application calls for it. The “Exposure Time” is the manually entered time used at each exposure. It represents the time that the substrate is exposed using the digital mask (defined by the user's artwork), which is projected onto the DMD (Digital Micro-mirror device). At the expiration of the elapsed time, the DMD stops reflecting, therefore cutting off all exposure light.

Time values may be entered to the hundredths of a second but up/down arrow adjustments will only vary amounts by whole seconds. Experimentation is recommended to ensure that variables of cure time, quality of material, temperature, humidity, etc. allow a given process combination to fall within boundaries of consistent, predictable results and expectations. In the "Exposure Timer" section there are two ways to see how much time has elapsed in the single exposure.

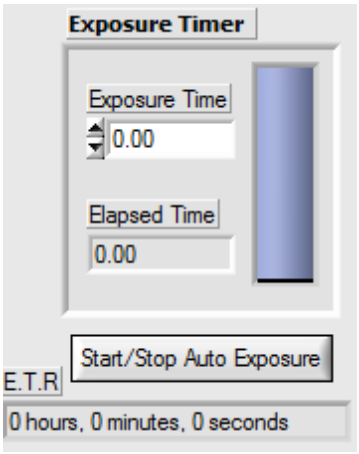


Figure 7.7.3.1: Exposure timer window

The "Elapsed Time" box show the exact amount of time that the substrate has been exposed for, while the blue bar gives a visual indication of the amount of time. Both of these only refer to the amount of time elapsed in a single exposure.

If multiple exposure are being done, the E.T.R. (Estimated Time Remaining) will give the best estimate of the amount of time that will elapse before the complete exposure series will be finished.

Finally, the "Start/Stop Auto Exposure" button gives the user complete control over the process. This button is used to control all exposure functions (except Time Series and Exposure Matrix). Both single and series exposures are stopped/halted with this button. Note: The exposure process will stop automatically after completion, the only reason for manually stopping the process with the button is if the user does not want the process to finish (because of user error, incorrect substrate placement, etc.).

7.8 Time/Height Series

A time series is used to find the appropriate exposure time for a specific application. It is an automated way to expose a series of shots at different times (refer to "Exposure Time Tuning"). The height series, which is accessed through the same window, is an automated way to expose a series of shots at

different heights in order to find the correct focal height of the system (refer to "Focal Height Tuning")

The time/height series window can be seen in *Figure 7.8.1.* The window can be accessed through the "Options" menu at the top of the *Auto Stage*™ program. There are seven fields that must be filled in on the window.

Initial Exposure Time (s)
This option has dual purposes, the first is to set the initial exposure time for a time series, and the second is to set the exposure time for all the shots in the height series.

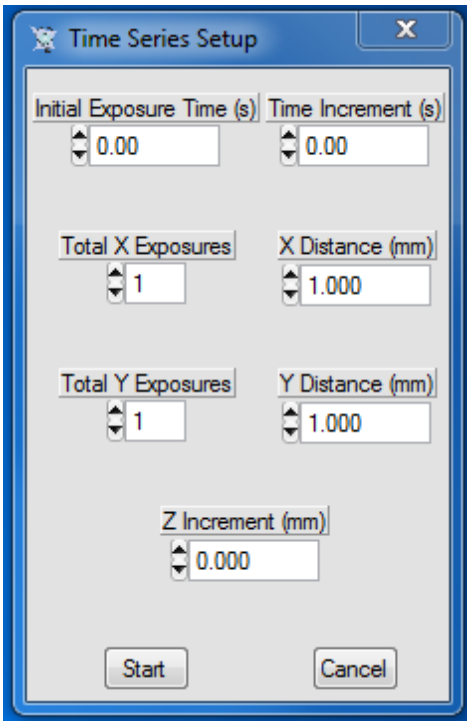


Figure 7.8.1: Time/Height Series Options Window

Time Increment
Option allows the user to set a specific amount of time that the exposure time should increase for each shot in the series. For example, if the initial time is 1.20 seconds and the increment is set to 0.10 seconds then the exposure time for the second shot will be 1.30 seconds, the third will be 1.4 seconds, etc. This parameter must be set to 0.00 when doing a height series.

Total X Exposures
Setting allows the user to set the number of exposures along the x-axis. The "X Distance" is the amount of space, in millimeters, between each exposure along the x-axis.

Total Y Exposures
Setting allows the user to set the number of exposures along the y-axis. The "X Distance" is the amount of space, in millimeters, between each exposure along the y-axis. For example, if the X Exposures was set to 2, and the Y Exposures was set to 3, then the array in *Figure 7.8.2* would be the result.

Z Increment
Option allows the user to do a height increment or decrement (a decrement can be done by adding a minus sign in front of the number). This box must be set to 0.00 when doing a time series.

The figure below shows the stage movement and the order which the exposures are shot on the substrate. For more information on how to perform a time/height series, refer to "Executing a Time/ Height Series".

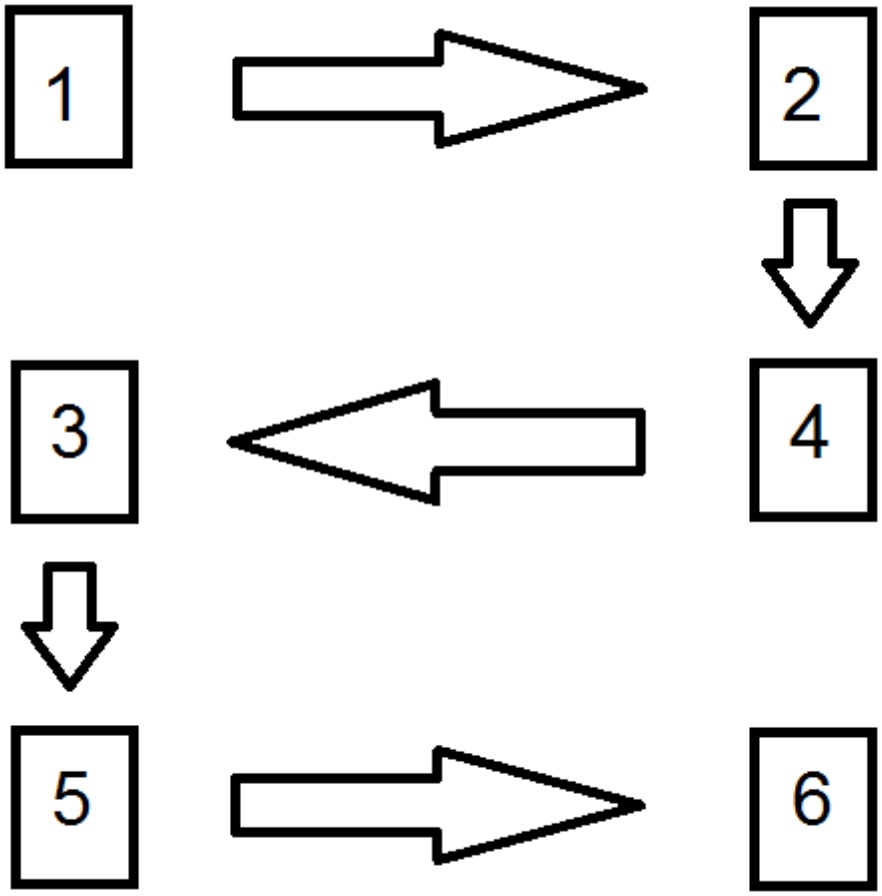


Figure 7.8.2: Image showing stage movement/exposure order

7.9 Exposure Matrix

The Exposure Matrix is a very powerful tool that allows the user to expose artwork (that may be made up of multiple smaller exposures) multiple times in a defined grid. For example, the user may have artwork that is larger than a single exposure window, and therefore requires multiple shots stitched together. Assume this artwork is composed of a 3 x 4 array of exposure windows. The exposure matrix allows the user to repeat the complete artwork (composed of a 3 x 4 array of individual shots) multiple times with a defined distance between the artworks in the x and y axis'. *Figure 7.9.1* shows the exposure matrix windows, which can be found under "Options" at the top of the Auto Stage™ program. There is a simple procedure located in the window itself as well as in the "Performing an Exposure Matrix" section of this manual.

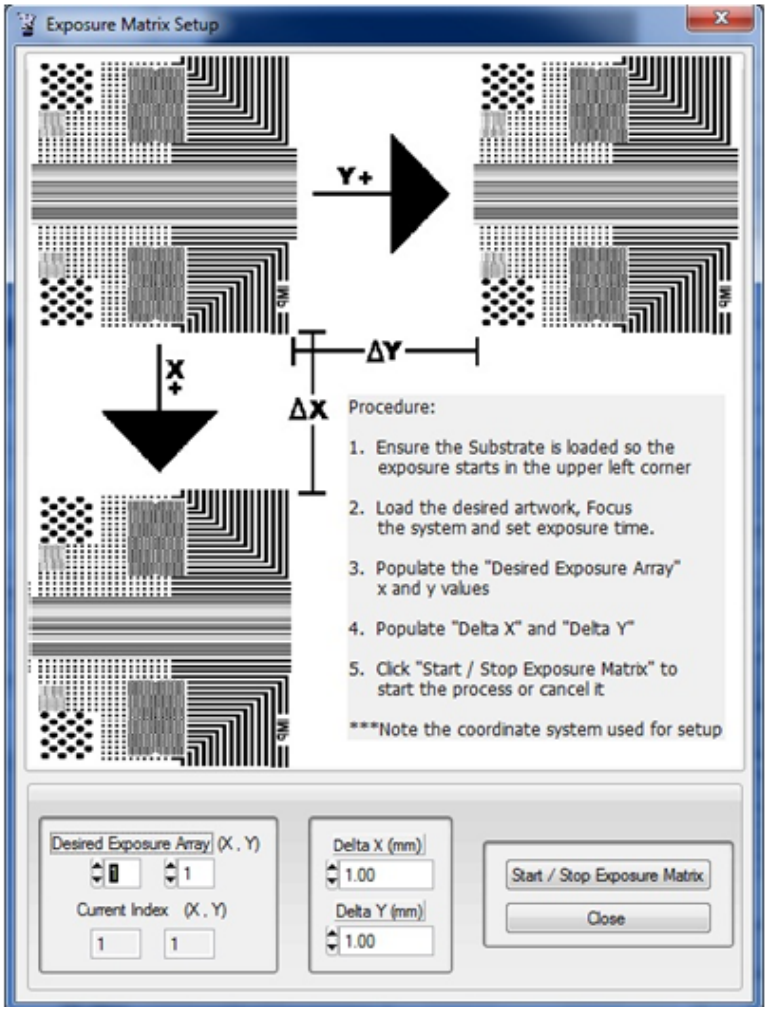


Figure 7.9.1: Exposure Matrix Setup window

INTELLIGENT
MICRO PATTERNING, LLC

Part VII

8 Lens Controller

The lens controller directly controls the automated zoom lens that is attached to the camera. It is essential in matching the focal height of the camera to the focal height of the projected image from the *Smart Filter*™. The software for the lens controller is separate from the main program. Choose the instructions appropriate to your lens controller software.

8.1 IMP Lens Controller

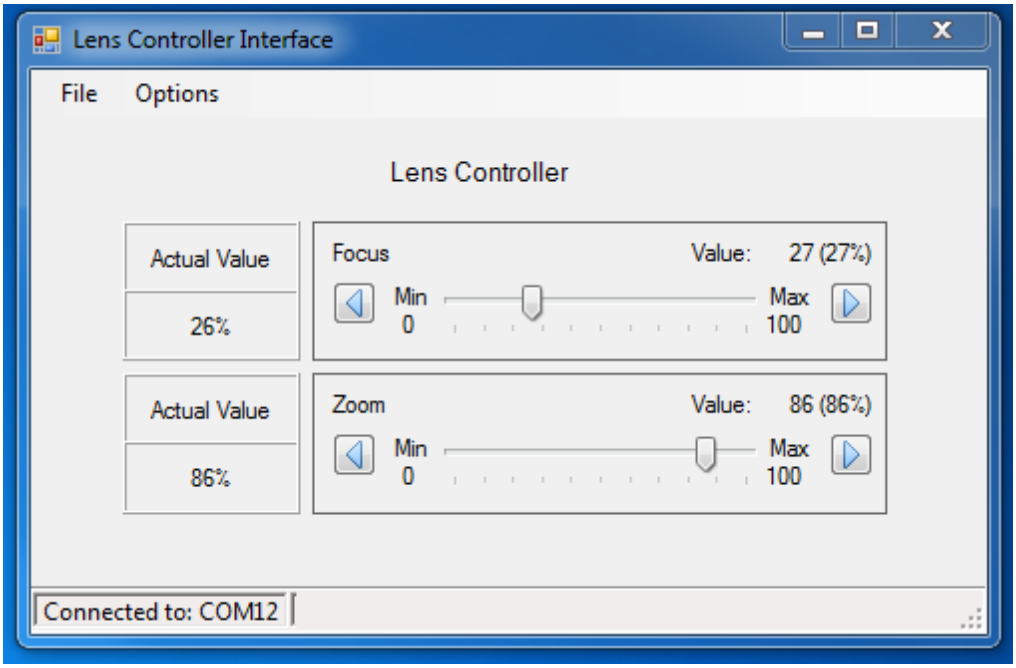


Figure 8.1.1: Lens Controller Main Panel

The lens controller software is very simple to use and intuitive. Opening the software is accomplished by double clicking the "Lens Controller" icon on the desktop. *Figure 8.1.1* shows the main screen on the software. There are two sliders one is for the focus and the other is for the zoom. The focus slider is actually a very fine zoom control. When changing these values the user must grab the slider with the mouse and slide it according to the appropriate direction (the higher the percentage the higher the zoom/focus). On the right side of the main window there is a "Value". This number is the value that the user sets for the lens. On the left side there are two boxes, one for zoom and one for focus. These are the "Actual Value" boxes. They show the actual value that the zoom lens is at, according to feedback

from the lens itself. Due to hardware limitations it is not always possible for the lens to go to the exact value that is set by the user, however the user set "Value" and the "Actual Value" should never be more that +/- 3% apart.

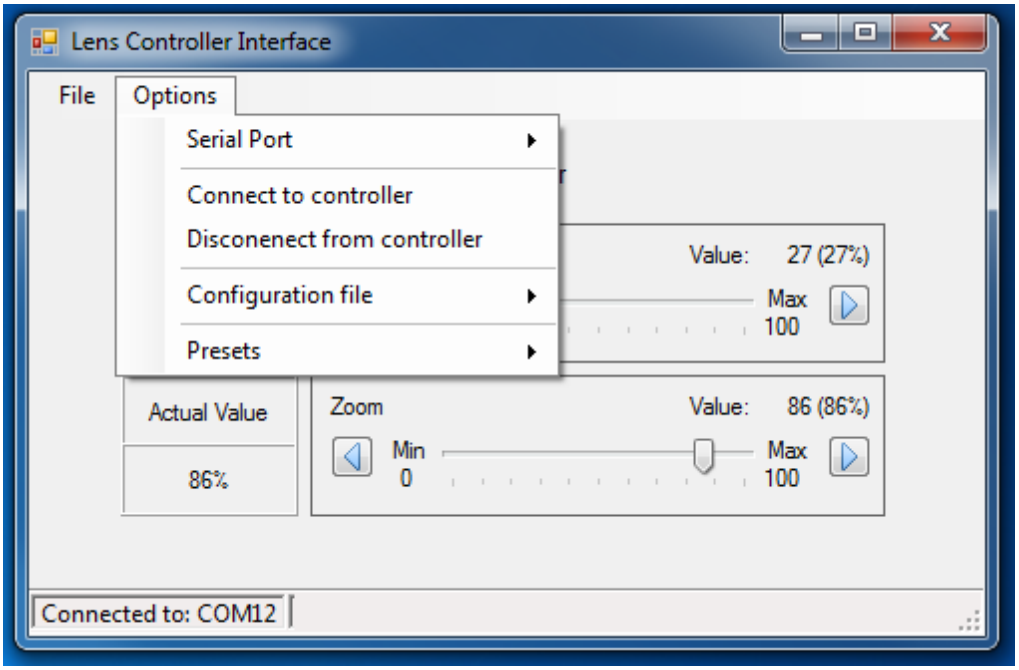


Figure 8.1.2: Options Menu

Options

Under the "Options" menu (*see Figure 8.1.2*) there are several different things the user can do. The first is to choose the correct serial port that the lens controller is attached. This is something that should be preset at the factory. It is just a simple pull-down menu showing the different com ports available. After selecting the appropriate port, the user must go back to the "Options" menu an select "Connect to controller". If the correct port was selected, then the program will successfully connect. It is also possible to disconnect from the lens controller, however this should only only be done at the direction of an IMP Engineer.

The next item in the "Options" menu is the "Configuration File", however this item is preset at the factory and should not be set by the user unless under the specific direction of an IMP Engineer.

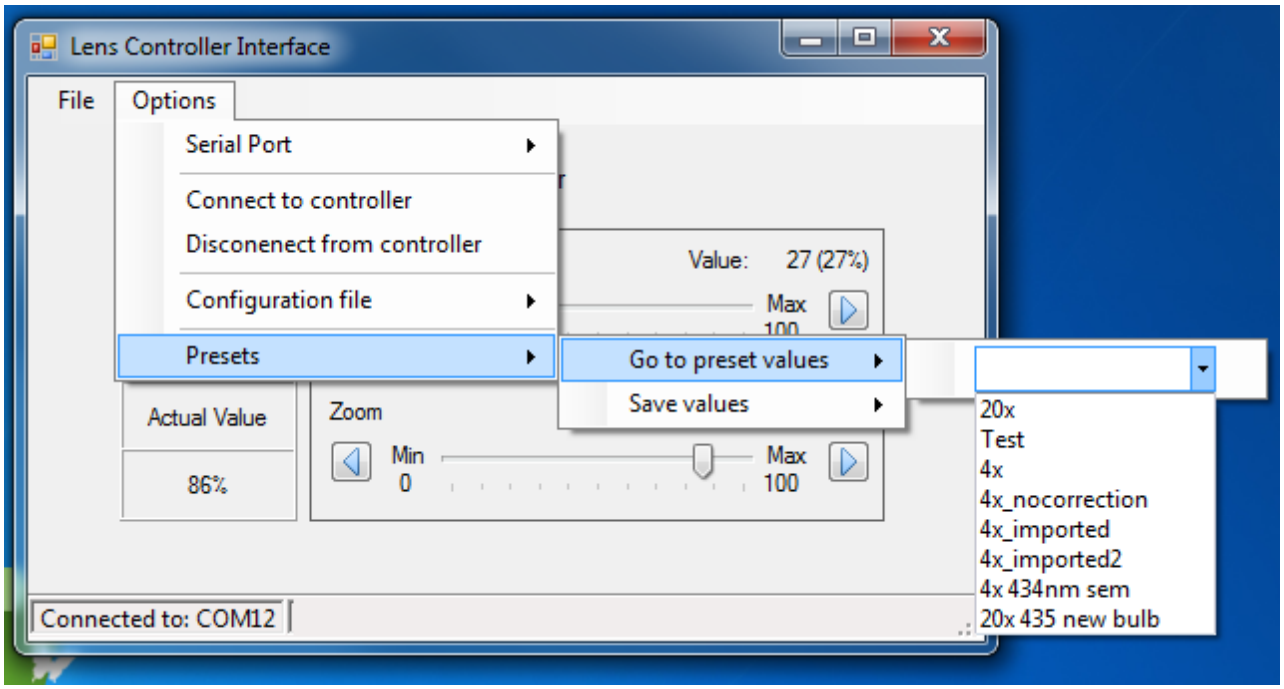


Figure 8.1.3: Go to Presets

Presets

The final item under the "Options" menu is the "Presets" menu. This is very important, because this is where the user will change the focal height settings when the objectives are switched. Whenever the objective or the wavelength of light is changed, it will also change the focal height of the machine. To change to a new preset go to "Options", "Presets", "Go to preset value", then choose the appropriate preset from the pull-down menu. To save a preset (once the zoom and focus values have been set), go to "Options", "Presets", "Save Values", "As New Preset" or "As an Existing Preset" (save as new preset if adding a new filter or objective, save as existing preset if re-tuning an existing objective or filter). If saving as a new preset, type in the desired name of the preset into the box and press enter (*see Figure 8.1.3*). If saving as an existing preset, choose the appropriate existing preset from the pull down menu (*see Figure 8.1.4*).

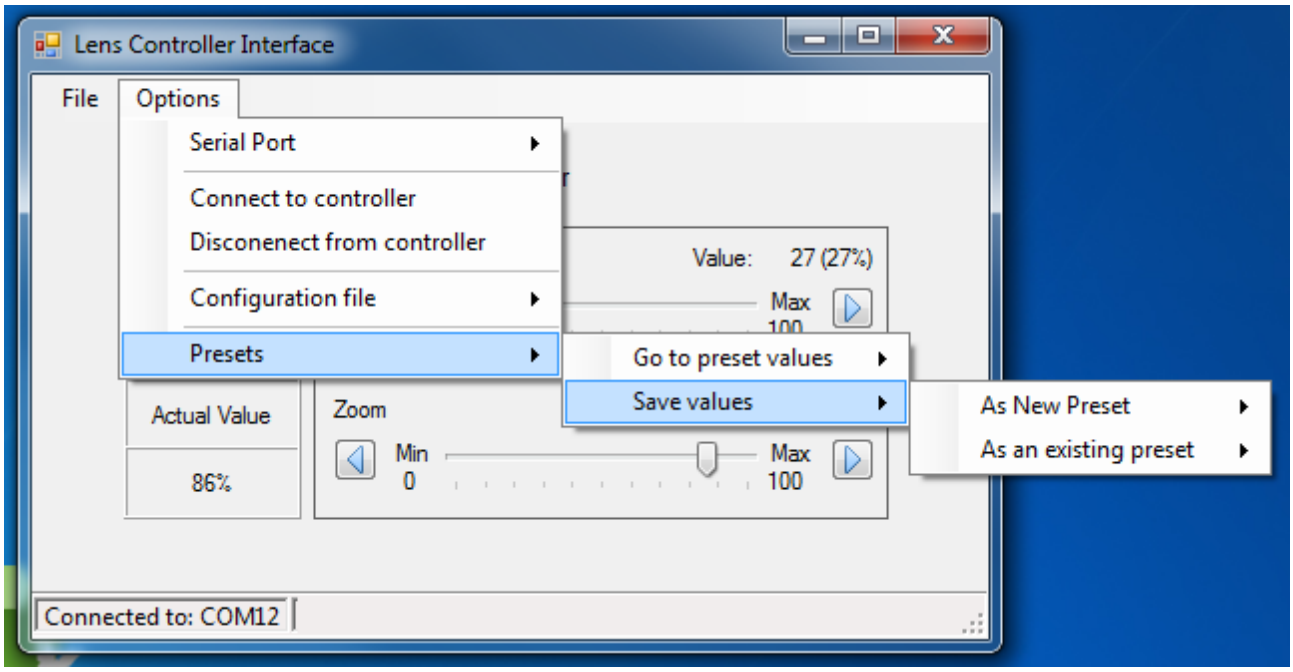


Figure 8.1.4: Save Presets

8.2 Image Labs Lens Controller

Start the Image Labs International Lens Controller application from the icon on the desktop; the application window will appear as in *Figure 8.2.1*.

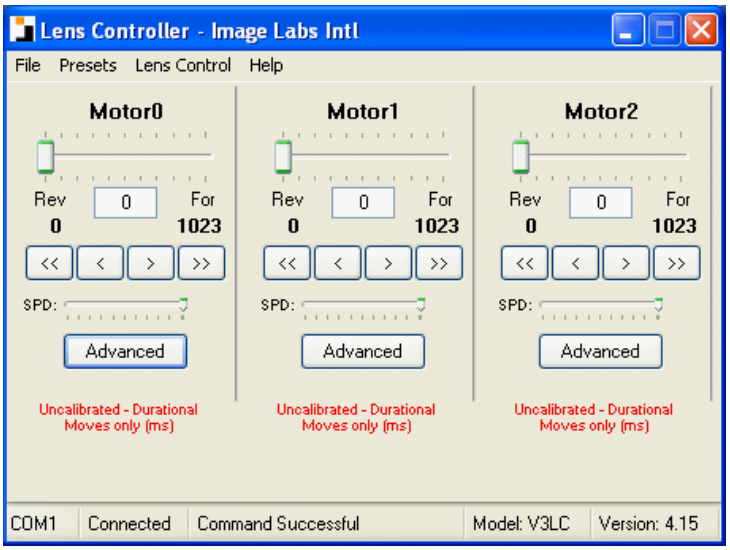


Figure 8.2.1: Lens Controller Application

The Lens Controller Application allows the user to control the following outputs on the Lens Controller

- Zoom Position
- Focus Position
- Iris Position
- Relay State

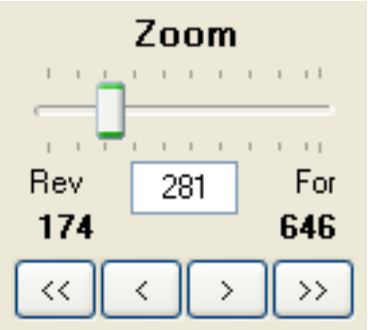


Figure 8.2.2: Motor Controller

Motor Control (Zoom, Focus)

For each axis of motion, there are several control buttons that allow the operator to change the position of that axis of motion. At the top is a slider bar control.

Slider Bar

The slider bar control represents the motor position once the axis limits have been found. To change the position of the slider bar, click and hold the left mouse button on it. Drag the mouse to the desired location and lift the mouse button to change the slider bar position.

As the slider is dragged, the text box should change its value. This is the value that the motor will be driven to if the slider were to be released. Once released, the motor will attempt to move to that location, and the actual location after movement will be shown in the text box.

Labels

The labels below the slider bar denote the direction that the lens motor will move when the slider bar position is changed. The bold numerical labels indicate the maximum and minimum positional values for the particular motor.

Text Box

The text box is used to specify positional based movements for the given motor. Normally it indicates the current position of the motor (if limits found). If the slider is moved, the textbox will now indicate what position the motor will move to if the mouse were released. Also, if a numerical value is typed into the text box and then <enter> is hit, the motor will attempt to move to that position.

Movement Buttons

Below the slider bar is a set of four buttons. These buttons allow the operator to move the motor in either direction, regardless of the calibration status. The single arrow buttons move the motor until the mouse is released, using the current speed during movement. The double arrow buttons act similarly, however they move at a speed of 255 regardless of what the speed was previously set to. Although the motor will finish its move if the mouse is released, it will also be stopped if the timeout is reached.

Presets

To access the preset menu click "Presets" on the menu at the top of the lens controller window (*see Figure 8.2.3*).

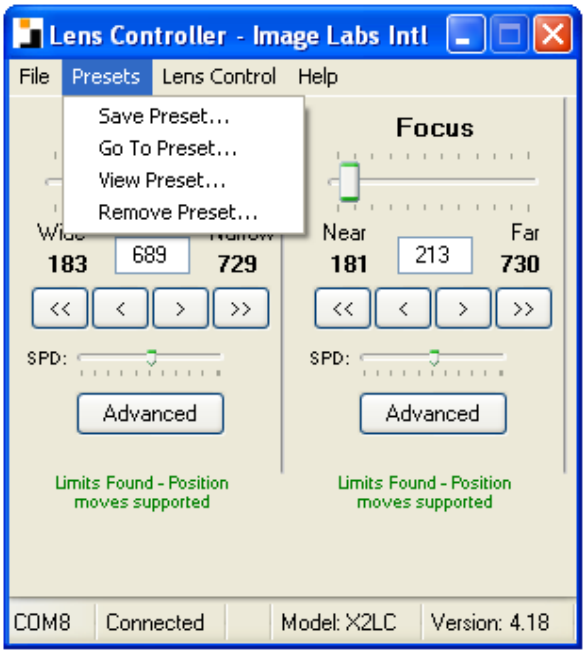


Figure 8.2.3: Location of the "Presets" menu

There are four separate options under the "Presets" menu. The "Save Preset" option allows the user both to save a new preset and to update/overwrite an existing preset. When the "Save Preset" option is clicked a new window will popup (*see Figure 8.2.4*). It will show the current positions of both the Zoom and Focus. Simply type the desired title of the preset under the "Name" box. If the user wants to update

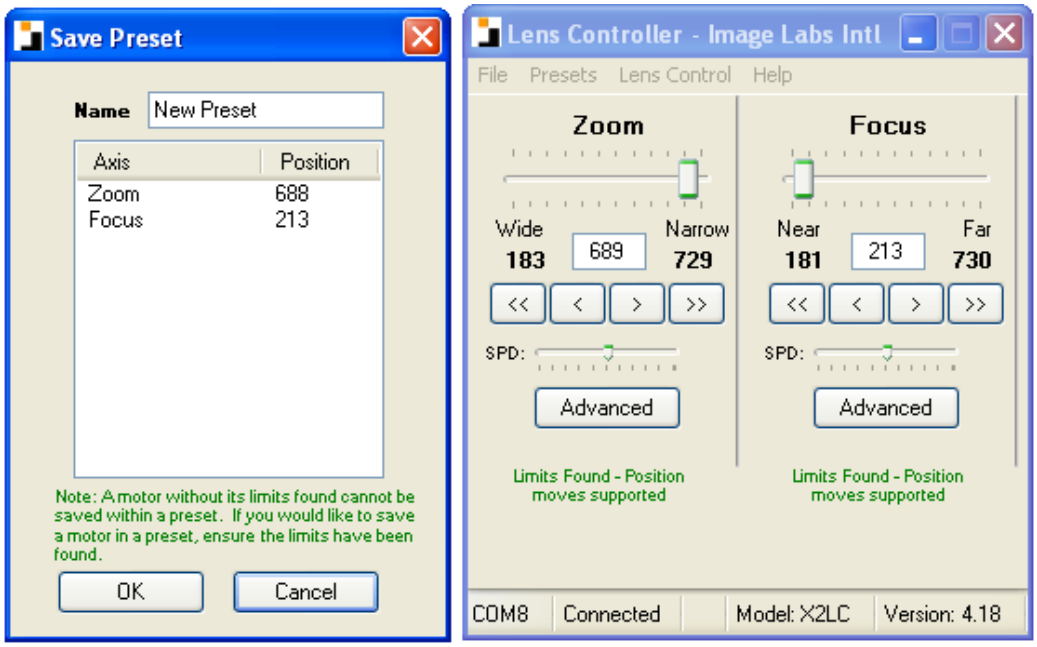


Figure 8.2.4: "Save Preset" window

or overwrite a specific preset, simply type the exact name of an existing preset in the "Name" box. To view a list of existing presets click on "View Preset".

To change the zoom and focus settings to a different preset value, click on "Go to Preset" (*see Figure 8.2.5*). Once the window pops up the user must choose the desired preset (according to hardware configuration) and then click "Move".

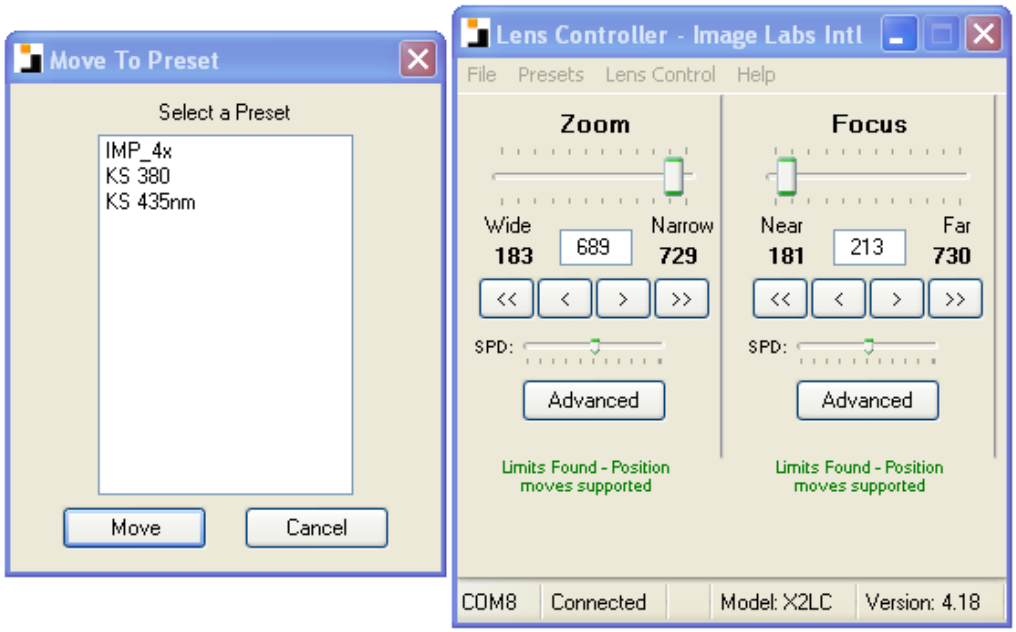


Figure 8.2.5: "Move to Preset" window

INTELLIGENT
MICRO PATTERNING, LLC

Part IX

9 Auto Stage Procedures

The following procedures outline the functions one can perform using the *Auto Stage*™ program. It is recommended that the user read through and become familiar with the "*Auto Stage*™ Program Overview" section of this manual before continuing or attempting to execute any of the following procedures. Also, please be aware of all Safety advisories before using the tool.

9.1 System Power Up

1. Ensure all cords, cables, and unit covers are in place and all system vents are unobstructed. Turn on the SF-100 Unit using the switch located on the side of the unit next to the main power plug. You should hear the system fan turn on inside the unit and feel a discharge on the left rear of the unit. Lack of proper ventilation may shorten lamp life, cause system shutdown, or failure.

2. Once the system fan and the filter wheel operation have been verified, turn on the computer and the monitor.

3. Finally, verifying that all covers are in place and the front panel is closed, turn on the lamp. This may be done by accessing the “Lamp Control” tab in the *Auto Stage*™ program, located on the PC desktop, and click the power switch button. (See “Lamp Control Tab” for program directions) When this is done, the lamp will start and within 1 minute you should see a rectangle of light at the substrate exposure area. Allow the lamp to stabilize for approximately 30 minutes to 1 hour before continuing.

9.2 Auto Stage Setup

1. Verify the Windows™ Desktop has the icons for *Auto Stage*™ by Intelligent Micro Patterning Note: If these icons are not located on the desktop, contact Intelligent Micro Patterning Customer Service for assistance.

2. From Windows™ Desktop, set the 2nd monitor (the SF-100 *Smart Filter*™) to extended desktop mode. To do this simply right-click the desktop to open a drop-down menu, then select "Screen Resolution." Under "Multiple Displays" select "Extend these displays." Finally, click "OK" to close the window and return to the desktop.

3. Start the *Auto Stage*™ program by double-clicking the icon on the desktop.

4. Input the User name and Password.

5. After logging in the “Load Settings” window will popup, select the appropriate profile (*see Figure 9.2.1*).

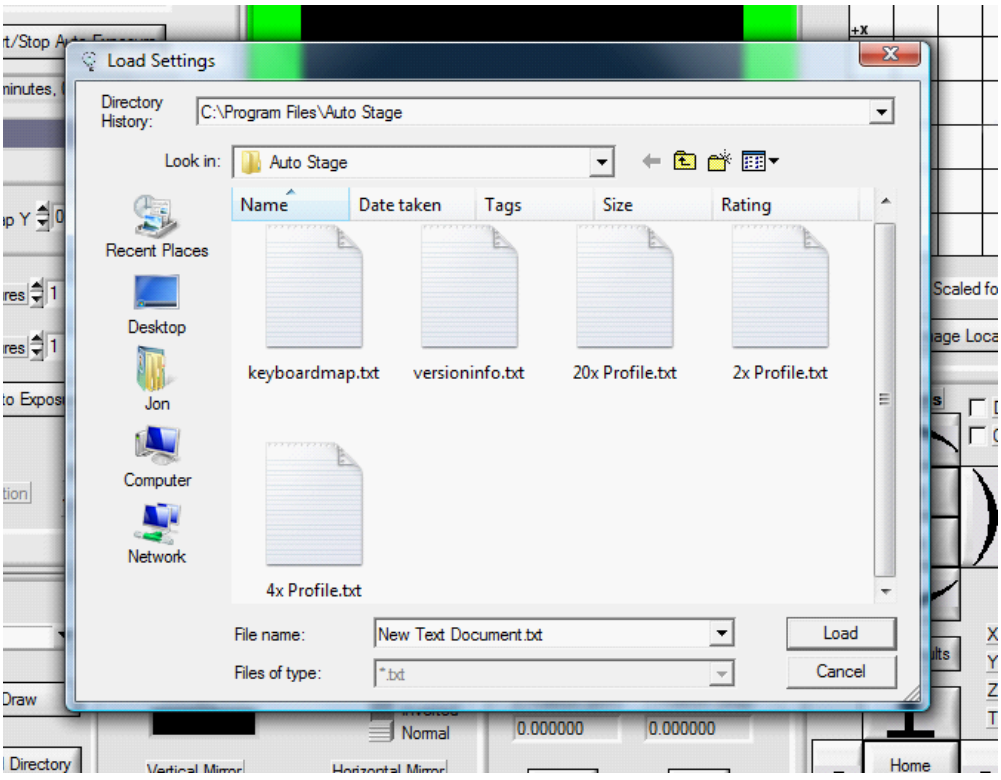


Figure 9.2.1: Load Settings popup

6. Direct your attention to the “Image Controls” section in the *Auto Stage*™ main screen for the steps below.

7. Select “Load Image” to begin browsing for the desired image or “Load Directory” to browse for a folder of images. Once the desired image/directory is highlighted, select “Load” again in the dialog window to bring the image into the Home Screen display.

   Note: Above the image display window, the “File History” drop-down will show the path to all images loaded during the session for quick selection and reloading.

8. In “Monitor List”, change monitor to “2” and left-click the “Draw” button. This will send the loaded image onto the SF-100 *Smart Filter*™ and illuminate it onto the stage or substrate, but will not expose it yet.

   Note: Select the “Draw” button while “Monitor List” is set to “1” to have image appear in Full Screen mode, where only the exposure frame portion of the full image will be viewable. To return to the Home Page screen, select the “ESC” key.

9. Finally, make sure the "Direct Control" button under the "Motion Controls" section is checked. You are now ready to expose!

9.3 Image Focus/Z Stage Alignment

1. Display an image on the computer screen for use in stage alignment. A simple image such as black text or lines on a white background is best suited for this purpose (“Focus” image is recommended). Note that this projected image is a left-right “mirrored” image of the computer screen. This can be compensated for by using the "Horizontal Mirror" (refer to "Bitmap Controls").

2. Place desired substrate (glass slide, metal piece, etc) on the stage within the exposure area. If using a glass slide, it is recommended you use one with a label (white area at one end) for focusing.

3. Access the camera in the stage program, to view the projected image from the substrate, by hitting the triangular “play” button. Make sure the Camera is set to 1280x960 Y (mono8) 7.5fps (this can be located in “Options”, “Camera”). Adjust the Z stage using the Motion Control buttons. As you move the Z axis above and below the focal plane, you should see the image go in and out of focus. Use the features in the Camera tab to adjust the Gain and Shutter Speed to gain a visible image that is not saturated.

4. When the image is visible in the camera window, click on the “Focus” button inside the *Auto Stage* program. An auto focus routine will adjust the Z height of the stage based on contrast to find the correct focal height. Once the focus routine is complete a prompt will pop up asking, “Is the image in focus?” If no is selected then a prompt will ask you to refocus (*see Figure 9.3.1*).

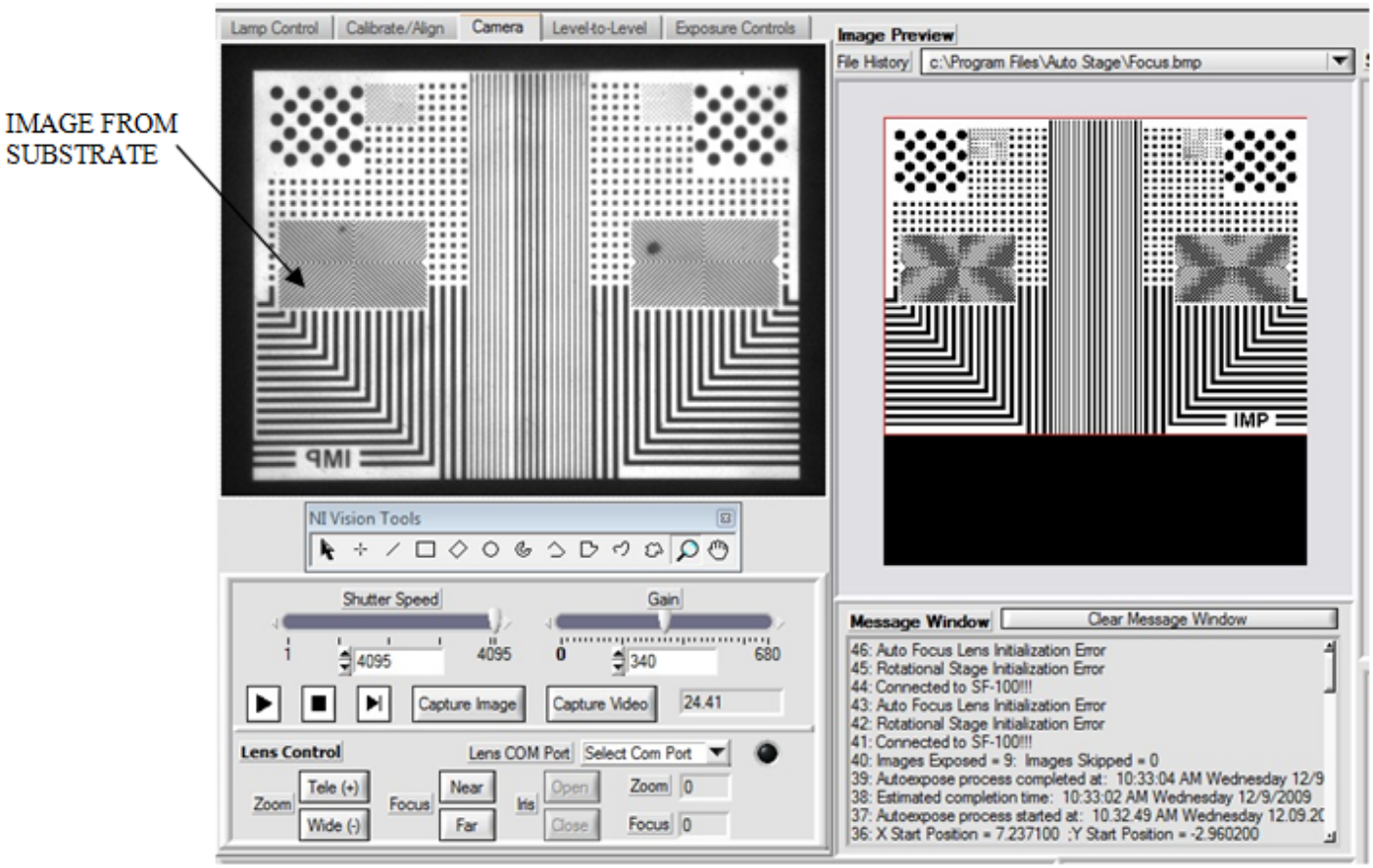


Figure 9.3.1: Camera View

9.4 Basic Substrate Exposure

Before continuing the steps below, verify that the "System Power Up" and "*Auto Stage*™ Setup" procedures have been completed.

1. Verify that the desired artwork is displayed in the "Image Preview" window (refer to "*Auto Stage*™ Setup").
   Note: Remember that all components of the visible computer screen image will be exposed

including any borders, menus or pointers. Clear the screen of all unwanted images before exposure. Also verify that the projected image at the substrate is oriented correctly; you may need to 'flip' the computer screen image to change the left-right mirrored orientation of the projected image.

2. Place your photo-reactive substrate on the stage under the exposure area.

3. Verify the projected image is in focus on the substrate. If not refer to "Image Focus/Z Stage Alignment"

4. Set the exposure timer for the desired exposure time.
   Note: A time series can be performed to test correct exposure time for a given substrate and resist (refer to "Executing a Time/Height Series").

5. Click on the "Start/Stop Auto Exposure" button located in the exposure controls for a single exposure.

   Note: Any auto exposure should be set up in the "Auto Expose Options". Click on the "Auto Exposure Setup", and the program will calculate the number of X exposures and the number of Y exposures. These can be modified to fit your needs. Make sure a value is selected for the overlap between exposures for the stitched shot. IMP recommends that a 20 pixel overlap be used (*see Figure 9.4.1*). After setting desired Auto-expose options simply click the "Start/Stop Auto Exposure" button (for more information refer to "Auto Exposure Options").

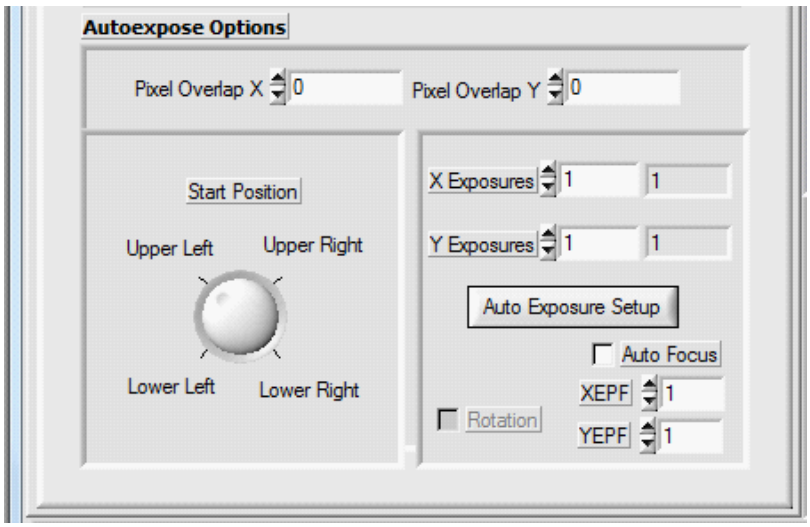


Figure 9.4.1: Auto Expose Options

6. Choose from the available options in the options menu and then click "Continue" (refer to "Start/Stop Auto Exposure Options").

7. The program will display a window alerting the user upon completion of the exposure. After completion the exposed substrate is ready to be developed and examined with a microscope.

   Note: Your developed substrate will vary in appearance depending on exposure and development times. You may need to experiment with both settings to achieve the desired results. Intelligent Micro Patterning has process engineers to assist you in your processing efforts. If you require assistance in this area, contact us for more information.

9.5 Align XY

The Alignment procedure need only be performed under the following circumstances:

- Initial Setup
- If the system has been severely jarred, moved, or bumped
- At the specific instruction of an Intelligent Micro Patterning Customer Service Engineer
- If the optics or objectives have been changed or removed

Note: If you are unsure of whether it is necessary to perform an alignment procedure, please contact Intelligent Micro Patterning Customer Service before proceeding.

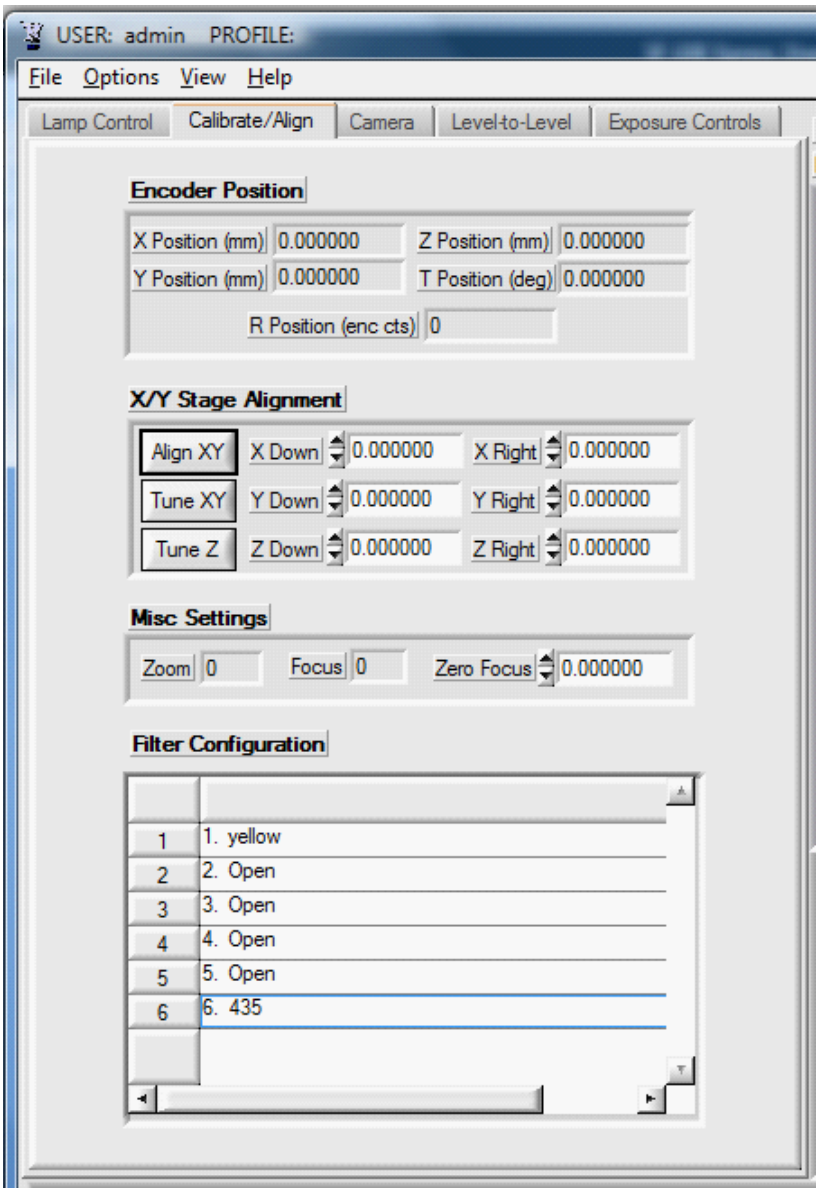


Figure 9.5.1: Align XY in the Calibrate/Align tab

If none of the above circumstances are valid and the system is operating correctly, there is no need to perform the Align and Tune procedures (*see Figure 9.5.1*). However, if the system needs to be aligned/ tuned, then the operator must click the "Calibrate/Align" tab, after completing steps 1-4 below. The operator must then click the "Align XY" button. Once the button has been depressed the message below will appear (*see Figure 9.5.2*).

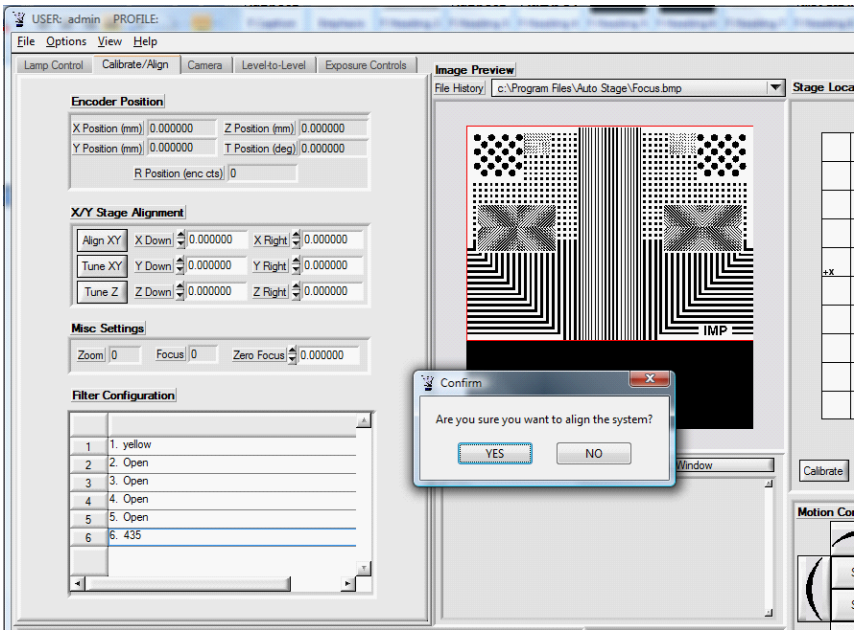


Figure 9.5.2: Confirmation prompt to Align the System

Alignment:

1. After selecting monitor 2 in the “Image Controls” cell, an image should be loaded to demonstrate that the *Smart Filter*™ and other image production systems are working properly.

2. Make sure the “Direct Control” box has been checked, this is located in the “Motion Controls” cell.

3. Move the X and Y axes stages to the approximate center of travel in both directions, this can be done by clicking "Home".

4. Affix a substrate, slide, or even a business card with a very fine feature, i.e. an edge, point, dot, or any other feature that will be easy to align with a small cross-hair image.

5. Select the “Align” button, then after selecting "Yes" at the prompt (*see Figure 9.5.2*) the small “plus” will appear on the left-side of the image.

6. Using the Motion Controls, move the substrate’s selected feature to align with the center of the “plus” as viewed on the camera window

7. When complete, select the “Align” button a second time and the “plus” will move to the right.

8. Again, move the stage to align the fine feature at this new location.

9. Repeat again: select “Align”, the image will move to the top of the image or to the right-side of the area. Again move the stage to it.

10. Repeat again: select “Align”, the image will move to the bottom of the image or to the left-side of the area. Again move the stage to it.

11. For the fifth time, select “Align” and the function will be completed. Numbers showing step count alignment correction values will appear in the “X/Y Stage Alignment” section located under the “Calibrate /Align” tab.

    Note: After the system has been aligned it will need to be tuned

9.6 Tune XY

The Alignment and Tuning procedures need to be performed under the following circumstances before any processing may be initiated:

- Immediately following the alignment procedure
- Initial Setup
- If the system has been jarred, moved, or bumped.
- Following the 6-month cleaning and lubricating process.
- If the optics or objectives have been changed or removed.
- If for an unknown reason the structures exposed along a stitch are misaligned.

The operator will need to enter the tune function by using the “Calibrate/Align” tab. The operator must then click the “Tune XY” button. Once the button has been depressed the message below will appear (*see Figures 9.6.1 and 9.6.2*).

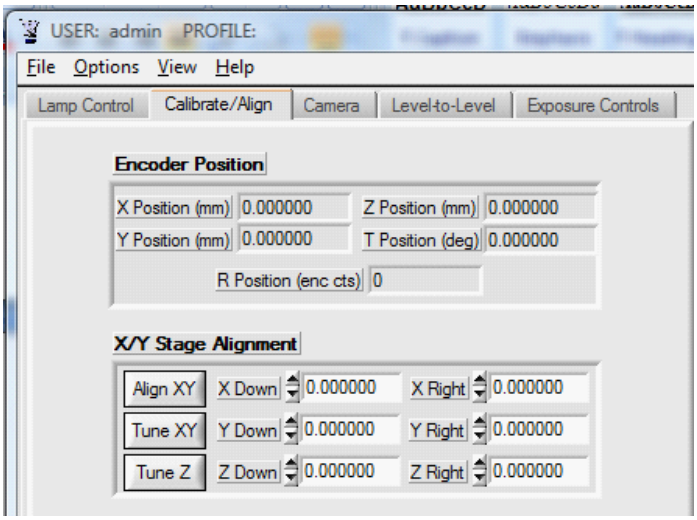


Figure 9.6.1: Tune XY in the Calibrate/Align tab

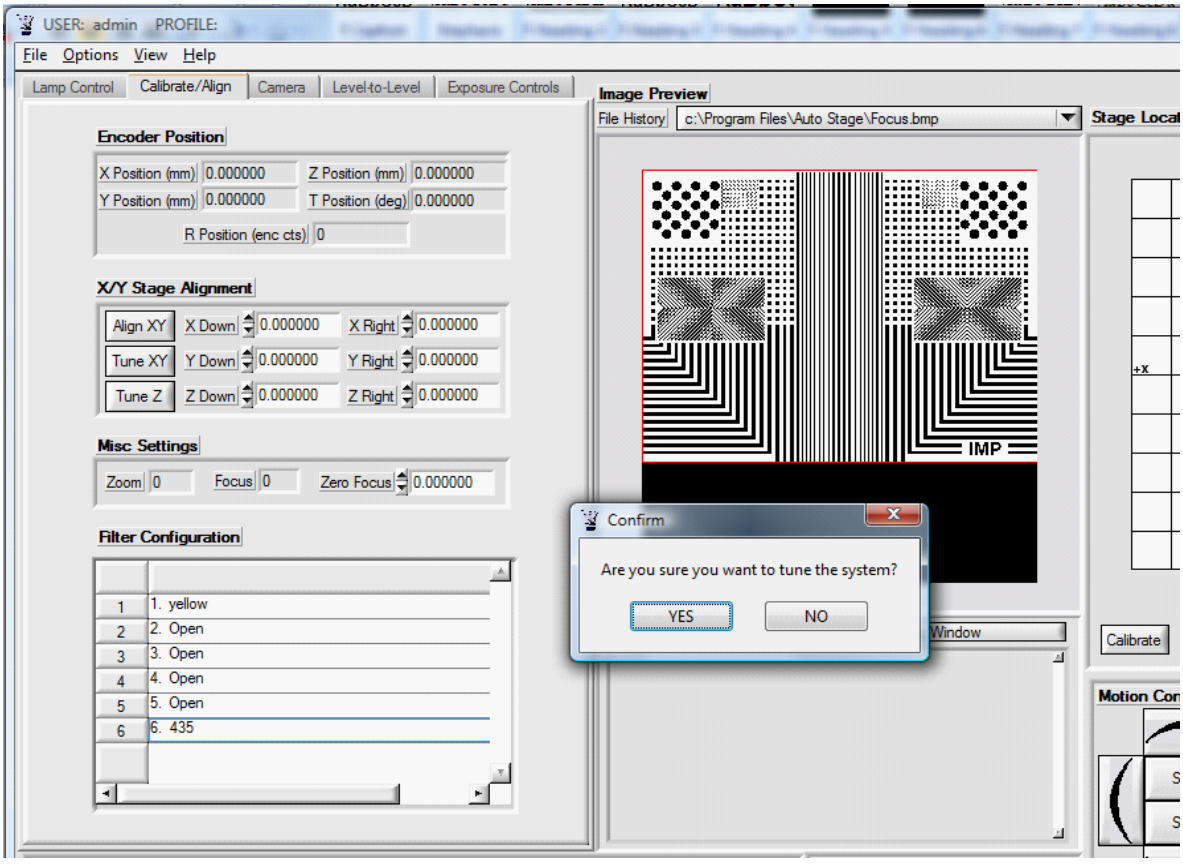


Figure 9.6.2: Confirmation prompt to Tune the system

Tuning

1. With the “Direct Control” box checked, move the X and Y axes of the stage to the approximate center of their travel ranges by pressing the "Home" button.

2. Prepare a minimum 2cm x 2cm substrate with unexposed photo-resist.

3. Under the “Exposure Control” tab, locate the “Exposure Timer” box. Enter the time needed to expose this particular test substrate.

   Note: At the Exposure Time box enter the time needed to expose this particular test substrate. Use a time that is approximately 30% lower exposure time than what is normally used because the resist will be exposed twice.

4. Place the substrate squarely on a full or over-sized image so it aligns in the center of the image and then press the “Tune” button

5. The program will then instruct the user to place or confirm placement of the substrate; when complete, click “OK”.

6. Two new images will be loaded and exposed onto the substrate. The second image will be exposed three times on the substrate.

   Note: When the tuning exposures are completed, the stage will use a Load function to bring the substrate out. Click “OK” and the stage will return to the previous location, and the next prompts for the tune process will appear.

7. Following this exposure, the program will ask the user to enter the numbers corresponding to results viewed after the development of the substrate patterns.

8. Following development, place the substrate where it can be viewed under a microscope. Please note that the exposed image on the substrate will differ from *Figure 9.6.3*, in that it will have crosses overlayed on the grid (refer to "Tune XY Example") and it will be mirrored and rotated 90 degrees (due to the optical characteristics of the SF-100). The following steps use the orientation of *Figure 9.6.3*, the orientation of your exposure will differ, so note the way the exposure is marked.

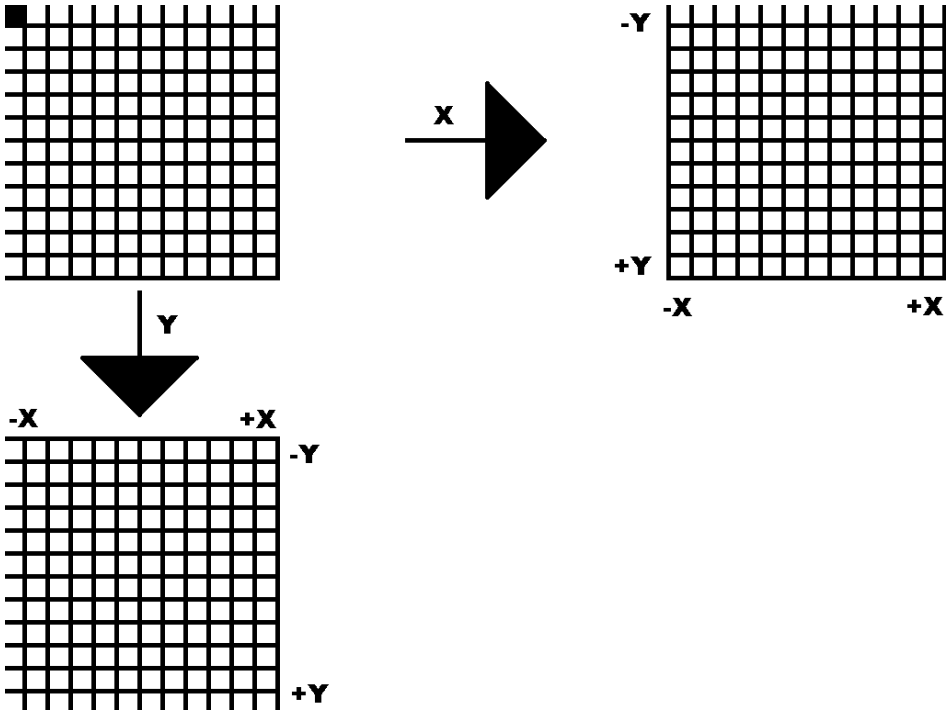


Figure 9.5.3: Tuning image that will be exposed onto the substrate.

9. There will be three areas of interest; two are sub-grids in the upper left and right quadrants and the third is in the lower left quadrant. These will each have circles surrounding one of the crossing grids. These circles denote the 0,0 (X,Y) coordinates of each sub-grid area.

10. The upper right or X-axis sub-grid will have an area where the crossing grids are perfectly aligned. The distance in grid cells from 0,0 to the center of this aligned point will be represented by coordinates. All coordinates are *positive-counting* as they move *away* from the main grid's solid corner and *negative-counting* as they approach this corner.

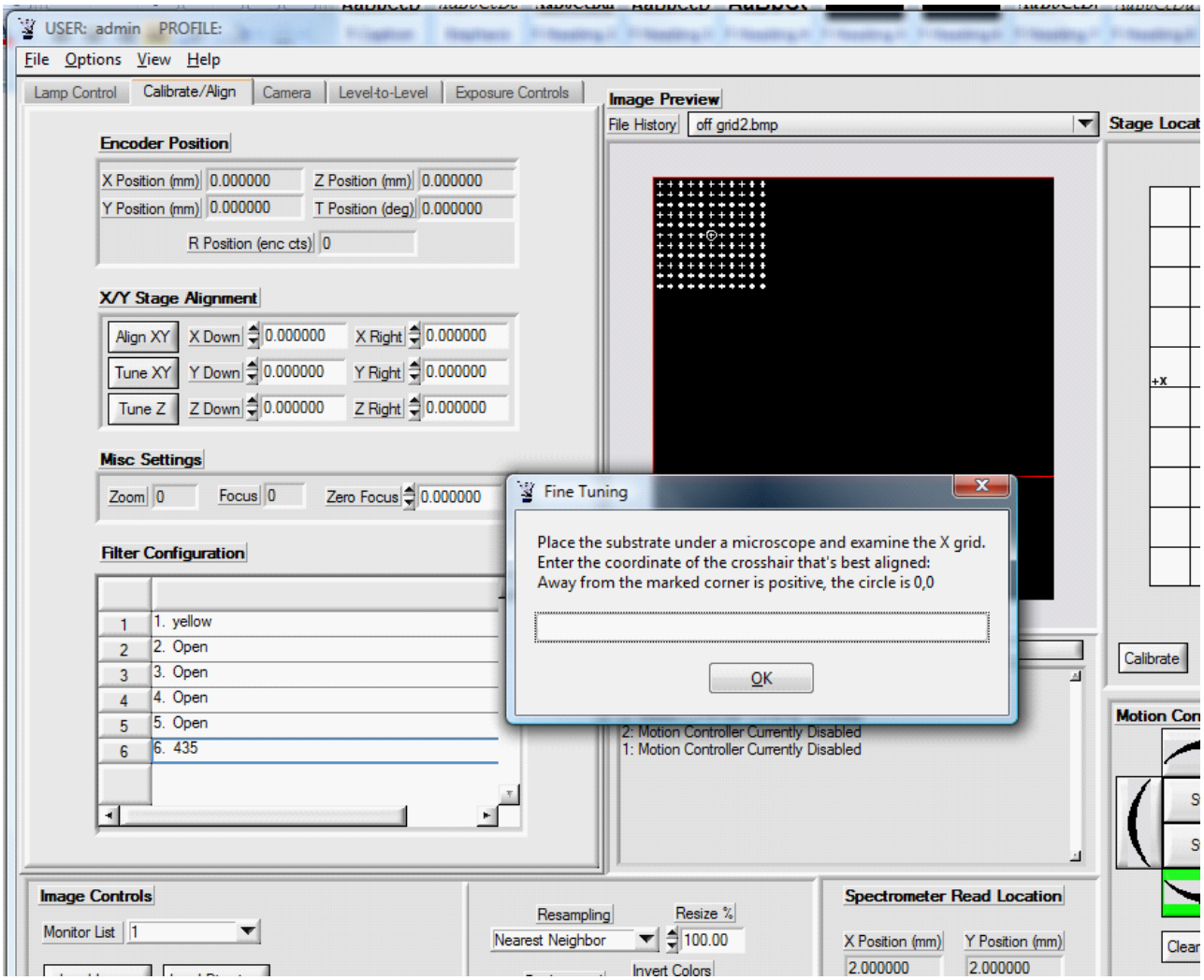


Figure 9.6.4: Tune prompt to input tuning parameters for the X grid

11. For example, if the perfectly-aligned point is two columns to the left and one row above the circled point, then the alignment coordinates are: -2,-1. This is what is to be entered into the box on the computer screen below. Then click “OK” to get the Y-axis dialog window (*see Figure 9.6.4*).

12. Repeat the procedure outlined above for the lower left or Y grid.

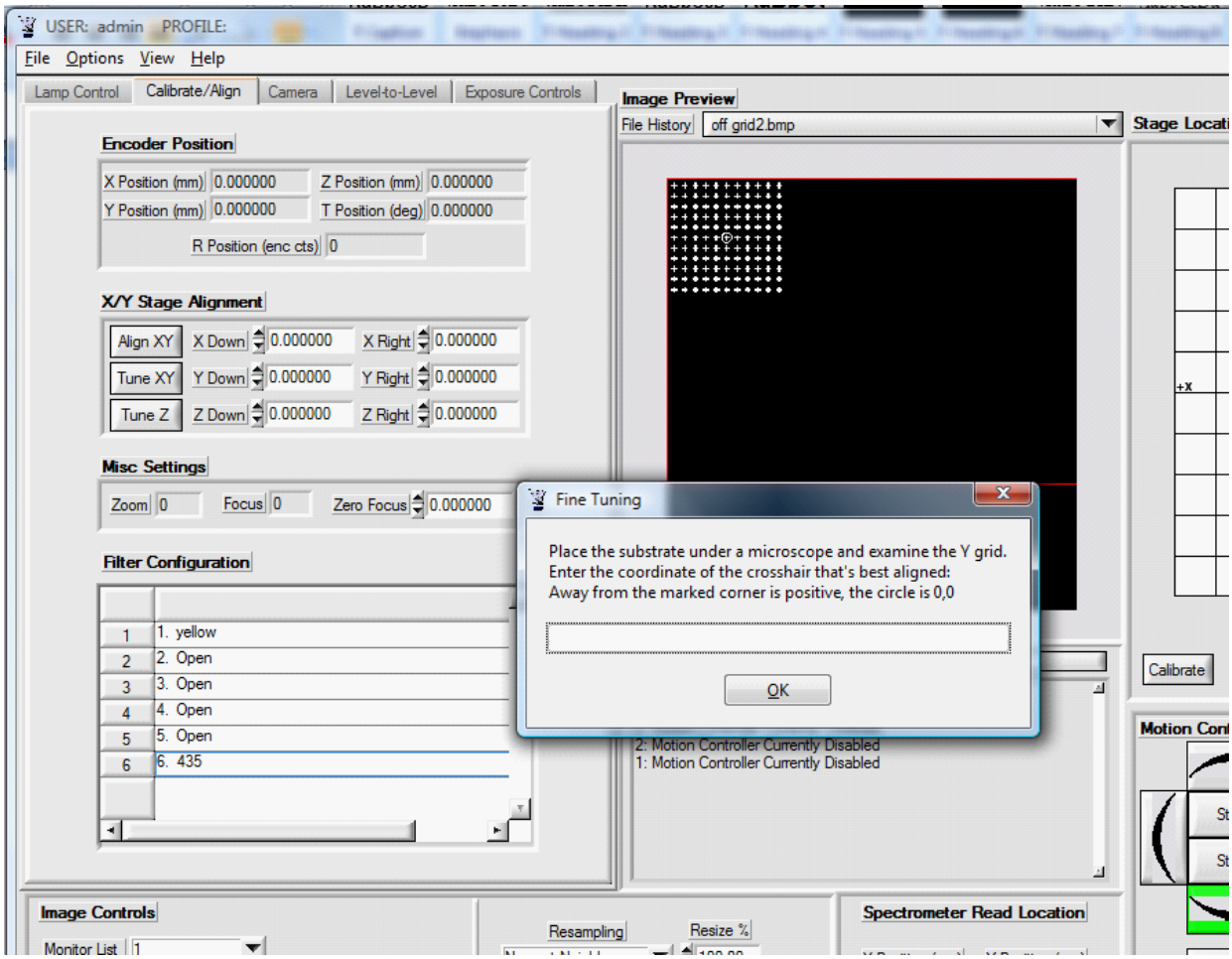


Figure 9.6.5: Tune prompt to input tuning parameters for the Y grid

13. For example, if the perfectly aligned point is directly below the circled point by only one row, then the alignment coordinates would be 0,1. This is what is to be entered into the box on the computer screen as prompted below. Then, click “OK” to finish (*see Figure 9.6.5*).

14. Before putting away the substrate, look at the upper-right hand sub-grid. It should show that the circled point is also the best aligned point. If this is *not* the case, there is a problem with the stage. Please verify that the "Home" command was executed in step 1 above. If the "Home" command was not completed, start this procedure over. If it was completed please see "Soft Reset of Automated Stage Controller".

15. If coordinates other than 0,0 and 0,0 were entered, the values in the “Move…” boxes will likely show slight changes to correct for fine alignment of the equipment.

16. Be sure to save the profile in order to preserve the new settings, if you do not save then the

correction performed above will not be saved.

To Save: Left-click the “Save Settings” button, located in the “Image Controls” section to preserve these new correction values. Create a new Profile name so that the settings can be loaded at a later time. IMP recommends that the provided Profiles do not get saved over.

NOTE: If there is suspicion that an alignment problem exists at *any* time, this procedure can be performed as many times as needed until satisfied. If problems arise, please contact IMP Customer Service for assistance.

9.6.1 Tune XY Example

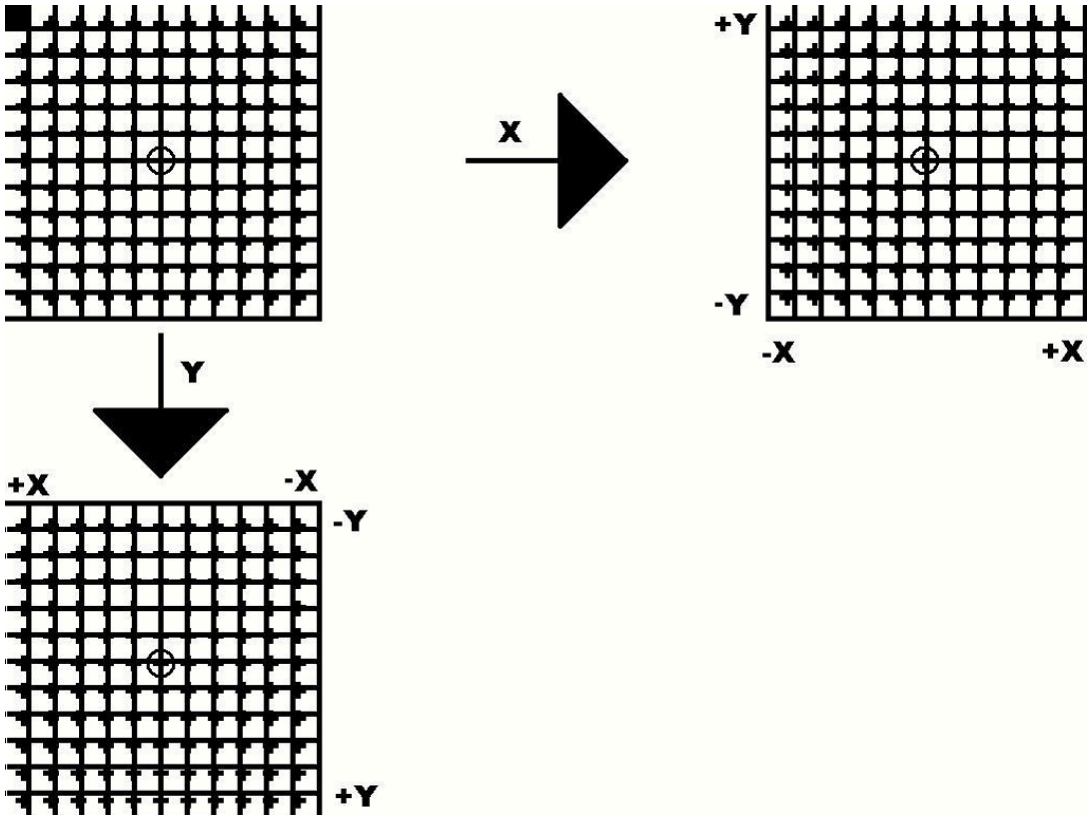


Figure 9.6.1.1: Example of Pattern that will be on Substrate after Exposure

Figure 9.6.1.1 shows the exposure that you should see once a Tune XY has been performed and the substrate is developed (the image in *Figure 9.6.1.1* will be mirrored and rotated 90 degrees on the substrate, due to the optics of the SF-100). The main grid (upper left quadrant) should already be aligned with the crosses (if it is not perform a "Home" command and rerun the Tune XY).

There will be three areas of interest; two are sub-grids in the upper left and right quadrants and the third is in the lower right quadrant. These will each have circles surrounding one of the crossing grids. These circles denote the 0,0 (X,Y) coordinates of each sub-grid area.

The upper right or X-axis sub-grid will have an area where the crossing grids are perfectly aligned. The distance in grid cells from 0,0 to the center of this aligned point will be represented by coordinates. All coordinates are positive-counting as they move away from the main grid's solid corner and negative-counting as they approach this corner.

The X-axis sub-grid in the above example is misaligned. In the X Direction the circled plus mark needs to be centered: as you can see in the image above the plus mark is off in the negative X direction, it is perfectly aligned two marks over at X = +2. In the Y direction, the circled plus mark is aligned, therefore the value is Y = 0. So, The value that would be typed in for the X-grid is "2, 0". Because, the center circle needs to moved over two in the positive X direction and zero in the Y direction.

The Y-axis sub-grid in the above example is also misaligned. In the Y Direction the circled plus mark needs to be centered: as you can see in the image above the plus mark is off in the positive Y direction, it is perfectly aligned two marks over at Y = -2. In the X direction, the circled plus mark is aligned, therefore the value is X = 0. So, The value that would be typed in for the Y-grid is "0, -2". Because, the center circle needs to moved over two in the positive Y direction and zero in the X direction.

9.7 Focal Height Tuning

The purpose of this procedure is to find the right focal height of the system which is critical for the process and imaging focus routines (manual and autofocus). To do this, a substrate that has already been properly exposed is needed, and will be used as a reference to coarse tune the focal height. There are basically 5 steps to follow to find the focal height of the system:

1. Coarse tune focal height for both the substrate and projected image
2. Coarse tune exposure time (Refer to "Exposure Time Tuning")
3. Fine tune focal height
4. Fine tune the exposure time
5. Verify settings

Note: Make sure that the optic train has been properly aligned and set up correctly before tuning the focal height otherwise this procedure will have to be repeated afterwards. Refer to " Optical Alignment Procedure".

9.7.1 Course Tune

1. Place the already exposed substrate on top of the chuck in such a way so that the exposed portion is directly under the objective.

2. Project the "focus" image on the DMD (Digital Micro-mirror Device). In the image controls section click the "Load Image" button and select the "Focus.bmp" file (this file is usually located in the application folder "C:\Program Files\Auto Stage\Focus.bmp").

3. Set the filter wheel position to the wavelength that you are focusing for i.e. if you are planning on using the 435nm filter to expose with, then choose this same filter (Refer to "Filter Position ").

4. Change the focus (Refer to "Lens Controller") of the camera so that the projected image is can be clearly seen in the camera tab. If the image does not come into view across the range of the focus setting, move the stage up/down on the z axis as needed (Refer to "Stage/ Substrate Movement"). Once the image comes into view, note the current focus value from the lens controller.

5. Next, adjust the focus so that the exposure on the surface of the substrate is clearly visible on the camera. Once the image comes into view, note the current focus value from the lens controller.

6. The goal of this step is to bring both the projected image and the previously exposed image into the same focal plane. To do this, move the z stage up 50-100 microns and try to focus on both the substrate's surface and the projected image as in steps 4-5. If the focus value of each gets further apart then the stage must be adjusted down from the original position. If the focus values become closer, simply adjust the stage in 5 to 10 micron increments until the focus value of both images converge.

7. When both images appear to be in focus, set the filter wheel position to the "Preview" filter and, using only the lens controller focus commands, bring both the images in focus again. It may not be possible, especially with the 20x objective, to get both the surface and the projected image exactly in focus (because the focal depth for the 20x objective is approximately 1 micron), however both should be visible. The actual focus will be between the focus of the surface and the projected image.

   Note: For this step it is essential that the z stage is not moved from its position found in step 6. The goal is to focus the camera at the current height of the stage (since this is the height that the projected exposure image is in focus). If the focal point is outside the range of the

focus adjustment, simply move the zoom control a small amount.

8. At this point both images should be in focus, and the filter wheel should still be in the preview position. The exposure time can now be course tuned. The focal height still needs to be fine tuned but that cannot be completed until the correct exposure time is found (Refer to "Exposure Time Tuning").

9.7.2 Fine Tune

1. Place an unexposed coated slide on the chuck (if the chuck is supplied with a vacuum feature turn on the vacuum pump to ensure that the slide does not move).

2. After manually bringing the image into view, press the autofocus button in the Motion Controls section.

3. After the program has performed an autofocus, the location of the stage on the Z axis is at the best focal height. Move the stage down in the Z axis ten times the Z increment (refer to table 2 for details on the typical values for the different reduction lenses). For instance, with a 4x reduction lens, the stage needs to come down (in the -Z direction) 0.1 mm.

4. Run a height series by using the time series option.

5. On the time/height series window, enter the values as shown in *Table 9.7.2.1* for the appropriate reduction lens.

Setting	4x	10x	20x
Initial Exposure Time	Photo-resist dependant	Photo-resist dependant	Photo-resist dependant
Time Increment	0.00	0.00	0.00
Total X Exposures	4	4	4

X Distance	2.00	0.600	0.300
Total Y Exposures	5	5	5
Y Distance	2.00	0.800	0.400
Z Increment	0.010	0.002	0.001
Initial Height	Height at current focus minus 100 microns	Height at current focus minus 20 microns	Height at current focus minus 10 microns

Table 9.7.2.1: The table shows an example of how to set up the height series.

6. Once the height series has finished, develop the substrate and perform a visual inspection of the exposed images. Find the best exposure height and make note of the height stamp on that image. The *Figures* below show the results of a 5x4 height series using a height increment of 0.010mm (10 microns), a 4x reduction lens, and initial height set at 100 microns below the initial focal height. It is evident that *Figure 9.7.2.1* is out of focus, and notice that as you get closer to *Figures 9.7.2.12* and 9.7.2.*13* the focus starts getting better and better; also notice that after *Figure 9.7.2.14*, the images start losing focus again.

   Note: Since the stage was moved down 100 microns and the increment was set at 10 microns, *Figure 9.7.2.10* is equal to the initial focal height.

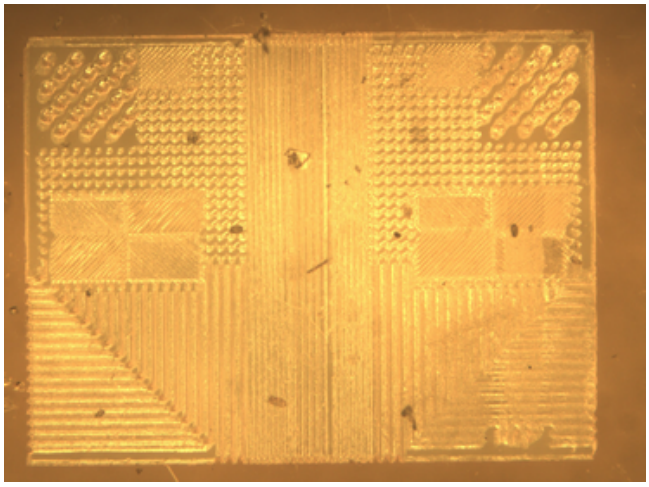


Figure 9.7.2.1

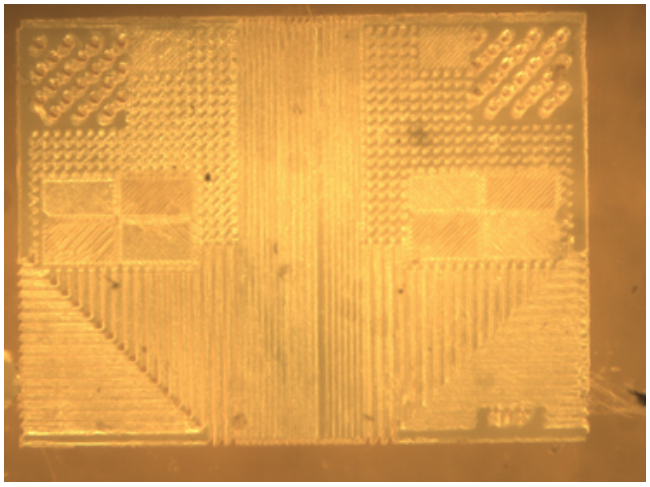


Figure 9.7.2.2

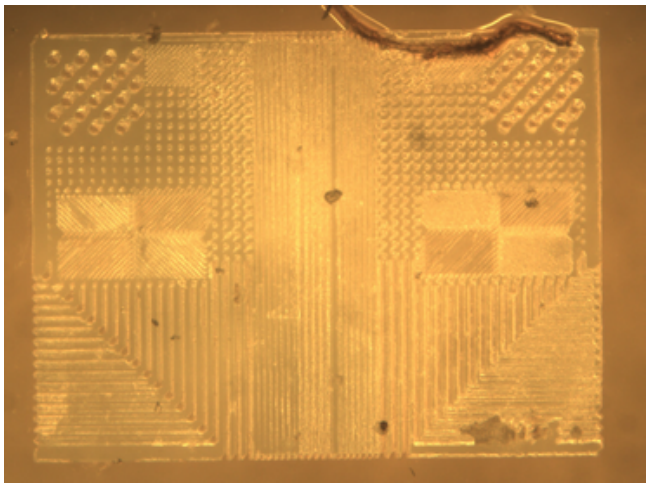


Figure 9.7.2.3

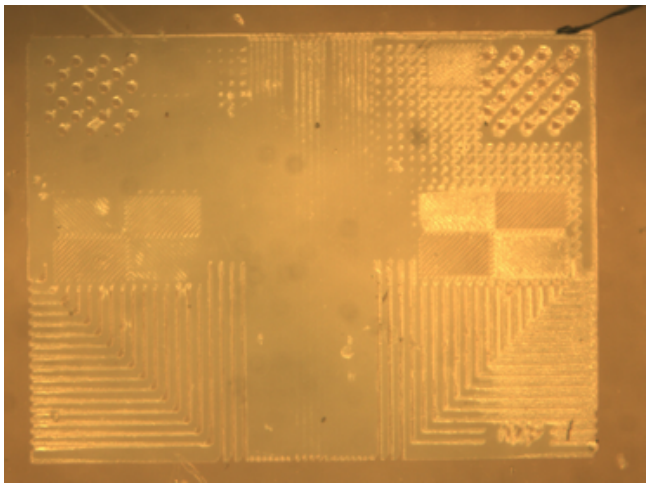


Figure 9.7.2.4

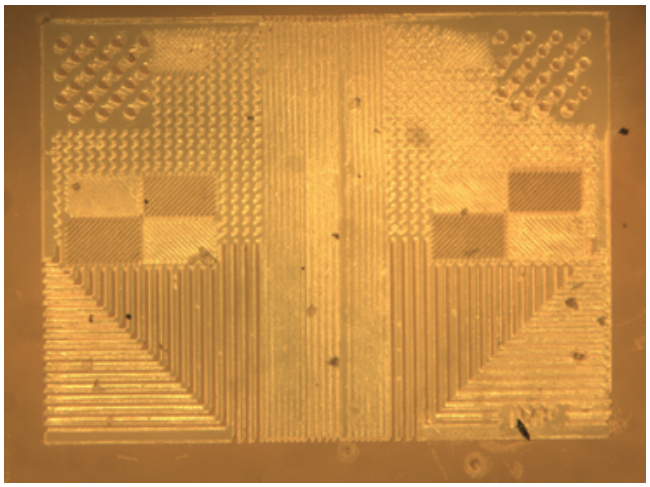


Figure 9.7.2.5

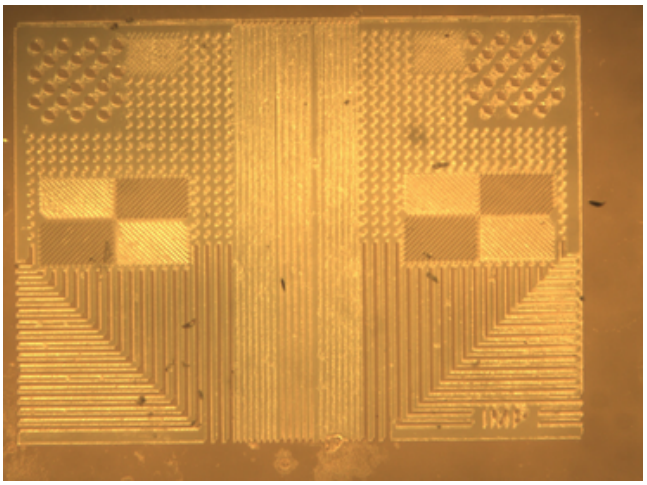


Figure 9.7.2.6

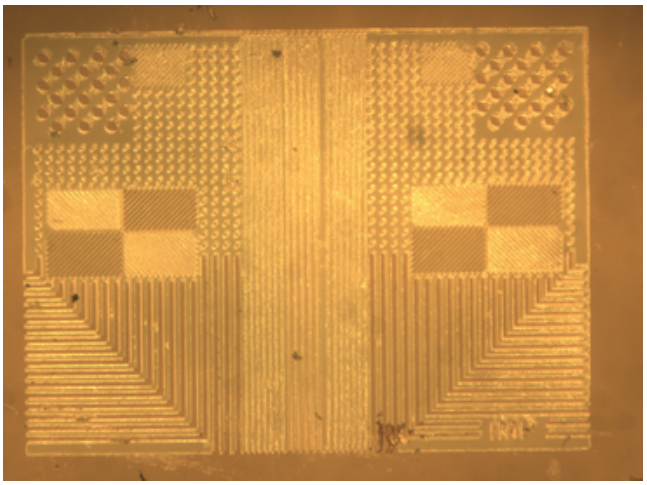


Figure 9.7.2.7

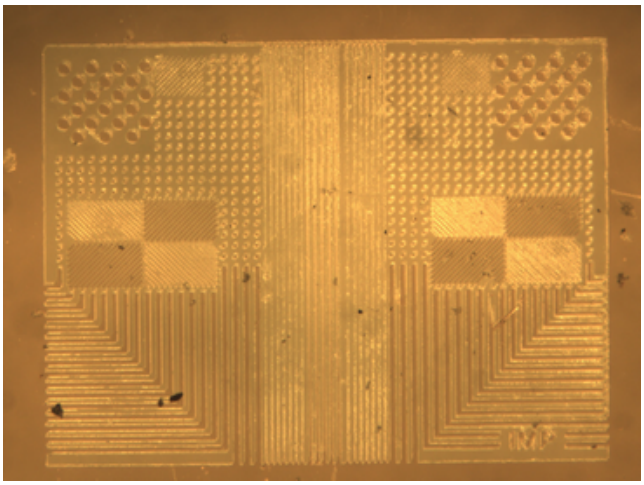


Figure 9.7.2.8

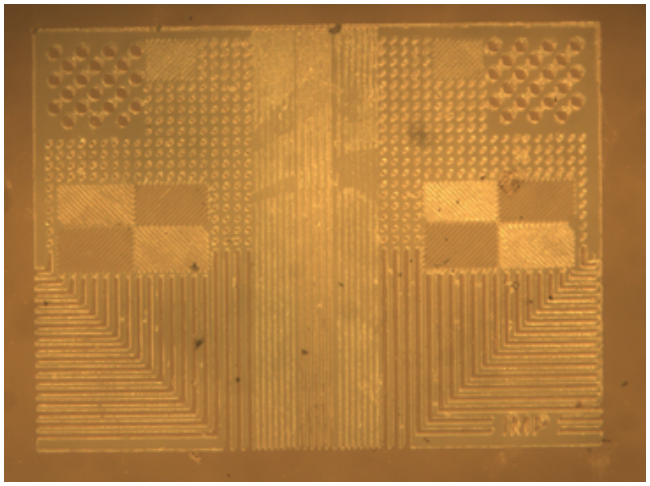


Figure 9.7.2.9

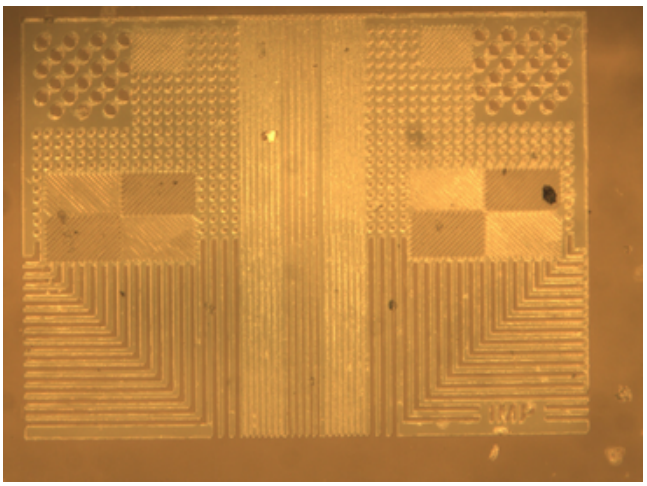


Figure 9.7.2.10

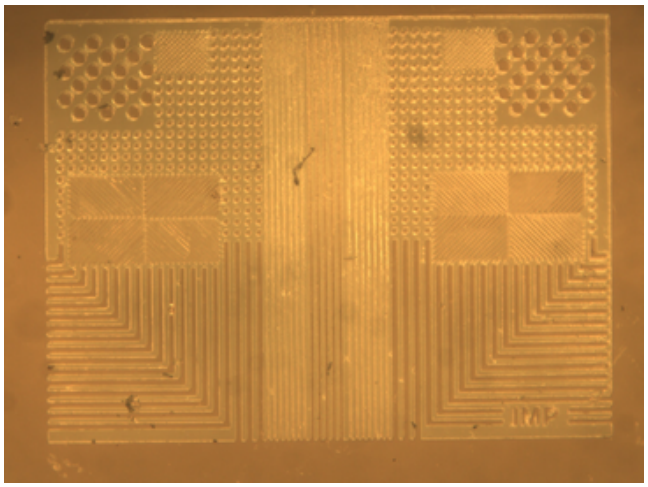


Figure 9.7.2.11

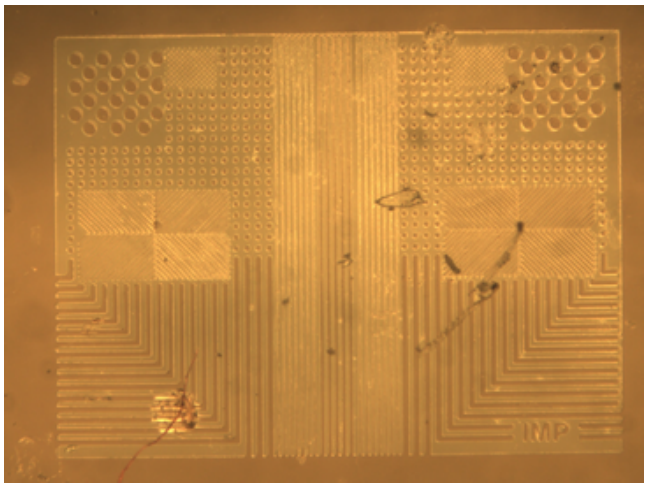


Figure 9.7.2.12

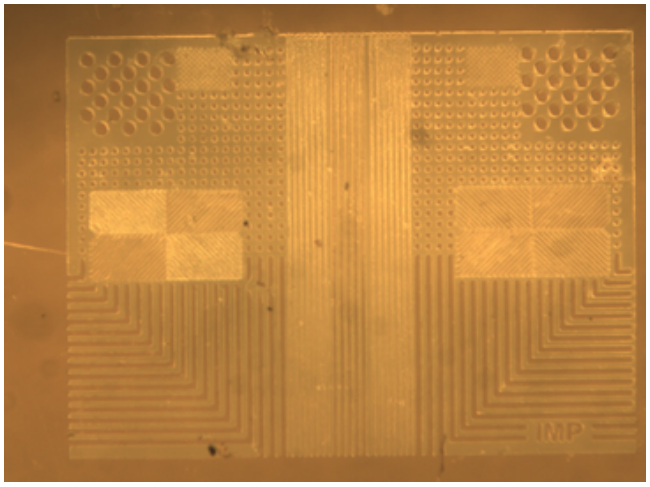


Figure 9.7.2.13

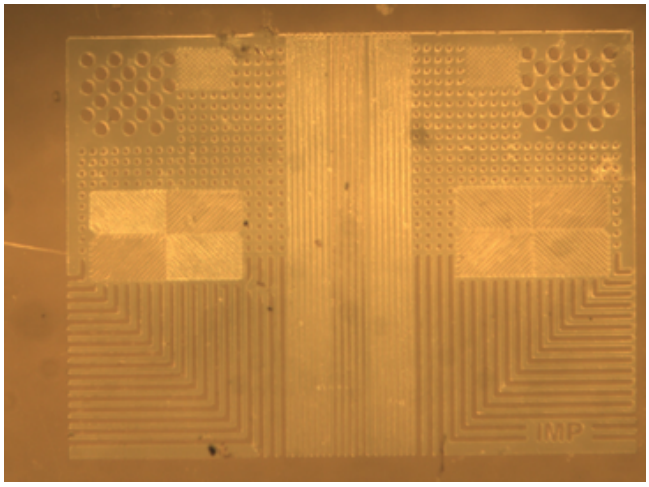


Figure 9.7.2.14

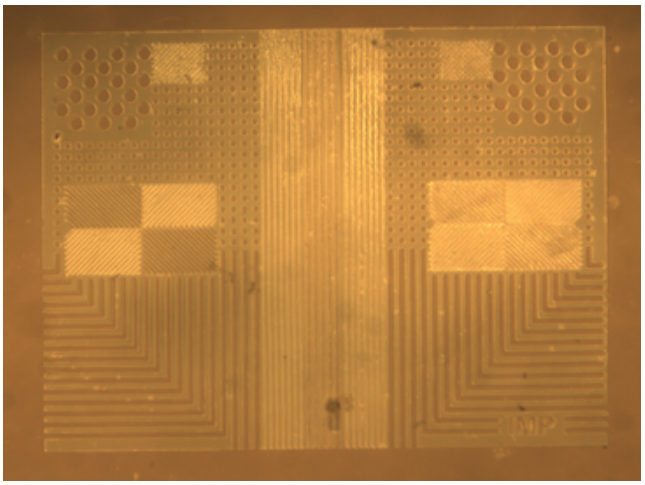


Figure 9.7.2.15

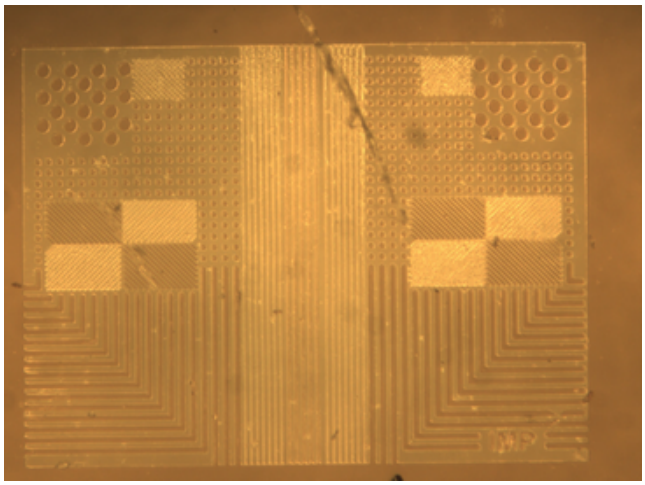


Figure 9.7.2.16

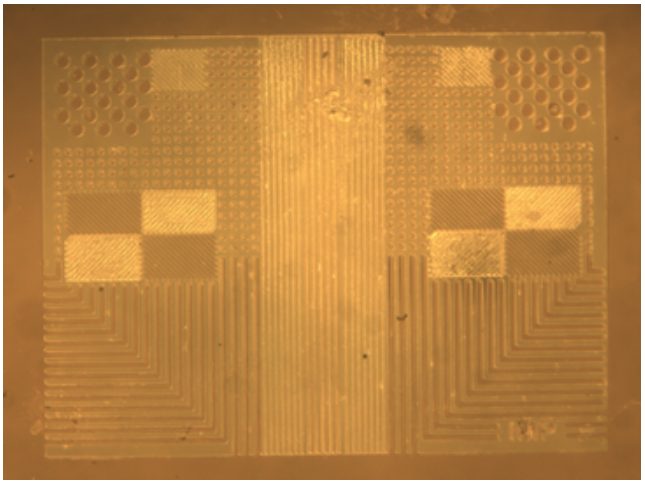


Figure 9.7.2.17

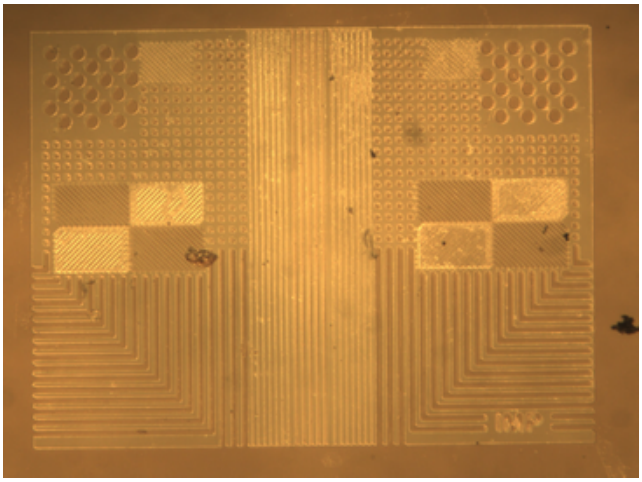


Figure 9.7.2.18

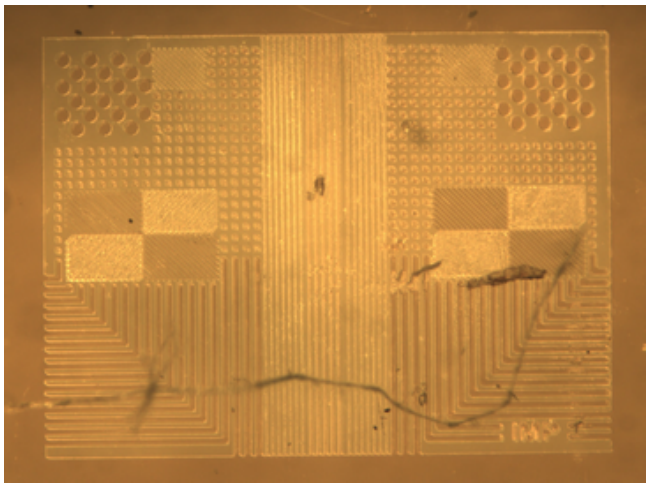


Figure 9.7.2.19

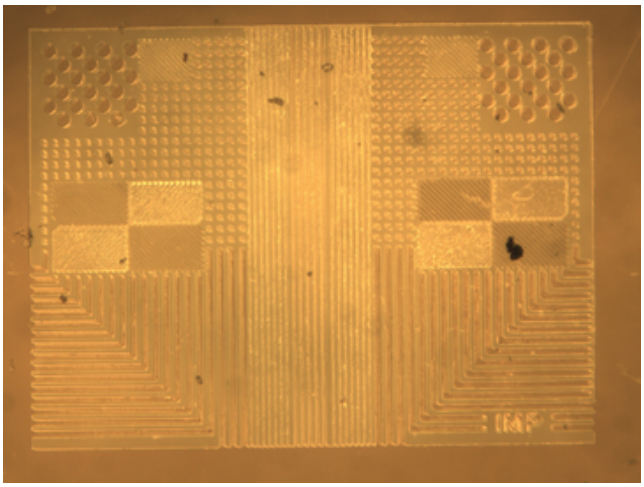


Figure 9.7.2.20

7. After determining the image with the better focus, move the stage down the number of steps necessary; to calculate the number of steps we use the following formulas:

   distance_to_come_down = ((Total_X_exposures * Total_Y_exposures) - number_of_steps) * Z_increment

   final_z_location = Final_exposure_height - distance_to_come_down

   For example: With a 4x reduction lens, if the best in focus exposed image is found to be the fifth, the Z increment is set at 0.010mm, and the total X and Y exposures were set to 4 and 5 respectively, then:

   distance_to_come_down = ((Total_X_exposures * Total_Y_exposures) - number_of_steps) * Z_increment
   distance_to_come_down = ((4 * 5) – 5) * 0.010 mm
   distance_to_come_down = (20 – 5) * 0.010 mm
   distance_to_come_down = 15 * 0.010 mm
   distance_to_come_down = 0.15 mm

   After the height series is complete note the Z stage encoder readout (Refer to "Encoder Feedback"), this is your final exposure height. In this example the final exposure height is equal to 8.5532mm:

   Final_z_location = final_exposure_height – distance_to_come_down
   Final_z_location = 8.5532mm – 0.15mm
   Final_z_location = 8.3532mm

8. After the stage has been brought to the final Z location and the same coated substrate is loaded back on the chuck (with an unexposed section directly under the objective), it is time to find the focus settings for the camera. Use the focus setting in the lens controller (Refer to "Lens Controller") to focus on the projected image at the new height, if necessary small adjustments to the zoom setting can also be made. After each adjustment to the focus (in the lens controller) click on the "Stop"  button in the "Camera Tab" and then click the  button to display the contrast ratio (refer to "Camera Tab"). Use the contrast value to zero in on the correct focal height (the higher the number the better the focus).

9. Save the current settings by clicking the "Save Settings" button, select the correct profile (i.e. 4X profile) and click the "Save" button.Also, save lens controller settings in the appropriate profile (Refer to "Lens Controller").

10. To make sure that the focal height was set properly, perform a time series at the height where the image is in focus, and set the time increment and height increment to zero. After developing the substrate all the exposed images should look the same and in focus.

11. In case the images appear out of focus, please perform another height series (as explained above), but this time use increments of half the previous increments. This will give you higher resolution and a better precision when finding the focal height.

    Note: Before closing the program make sure that the lens focus settings are saved in the correct profile, otherwise these settings might get lost and focal height will have to be tuned again.

.

9.8 Exposure Time Tuning

Course Tuning of exposure time can be accomplished using steps 1 through 4. Step 5 refers to fine tuning of the exposure time.

1. Place a coated slide on the chuck, if the chuck is supplied with a vacuum feature turn on the vacuum pump to ensure that the slide does not move.

2. Bring the image manually into focus, then using the "focus" button (located in the motion controls section) start the autofocus routine.

3. Once the image is in focus, the next step is to find the right exposure time for the substrate. This is done by performing a time series exposure. Run a time series by clicking "Menu," then "Options," and "Run Time Series".

   Note: A time series is a series of exposures at a fixed height where the exposing time is incremented for every exposure (Refer to "Time Series").

4. On the Time Series window, enter the values for initial exposure time, time increment, total X exposures, X distance, total Y exposures, Y distance, and Z Increments. For Shipley 1827 photo-resist, *Table 9.8.1* shows the typical initial values.

5. After exposing the time series, develop the substrate and examine it under a microscope. Simply choose the best looking exposure and note the exposure time on the time stamp. Not all versions of the *Auto Stage*™ program are equipped with the time stamp, if this is the case the user must count the exposures and and using the initial time/time increment calculate the exposure time of the particular shot. See *Figure 9.8.1* for exposure order.

   Note: At this point the exposure time is considered coarsely tuned. If fine tuning of the focus has not been completed, refer to "Fine Tune" before moving on to step 6.

6. It is sometimes necessary to run another time series with a smaller time increment. If this is deemed necessary, choose an initial exposure time so that the time series is run with the middle exposure equal to the optimum time found above. For example, if the optimum time found was 0.2 seconds with the 20x lens (using a 0.05s time increment): then the second time series should use a 0.01s time increment with the initial exposure time set to 0.1s. If this time series uses a 4 x 5 array, then the final time will be 0.3s (making the optimum time found in the initial time series the middle exposure).

Setting	4x	10x	20x
Initial Exposure Time	2.00	4.00	0.10
Time Increment	0.20	0.20	0.05
Total X Exposures	4	4	4
X Distance	2.00	0.600	0.300
Total Y Exposures	5	5	5
Y Distance	2.00	0.800	0.400
Z Increment	0.00	0.00	0.00

Table 9.8.1: Shows Typical Settings for Time Series

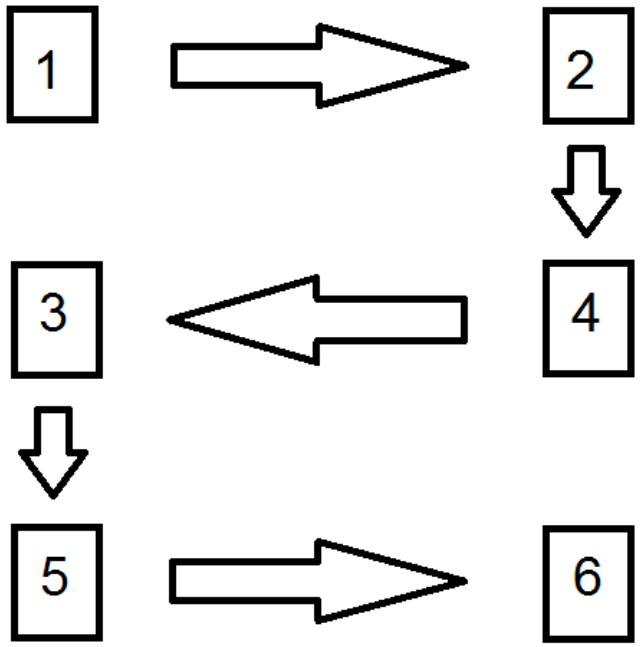


Figure 9.8.1: Image showing stage movement/exposure order

9.9 Level-to-Level Alignment

In the event a customer requires the ability to realign a previously exposed substrate for additional patterning, the process below can be used to accomplish this task. A minimum of two alignment marks are required on the substrate and bitmap file (for projected image) to accomplish this re-alignment (see Figure 9.9.1).

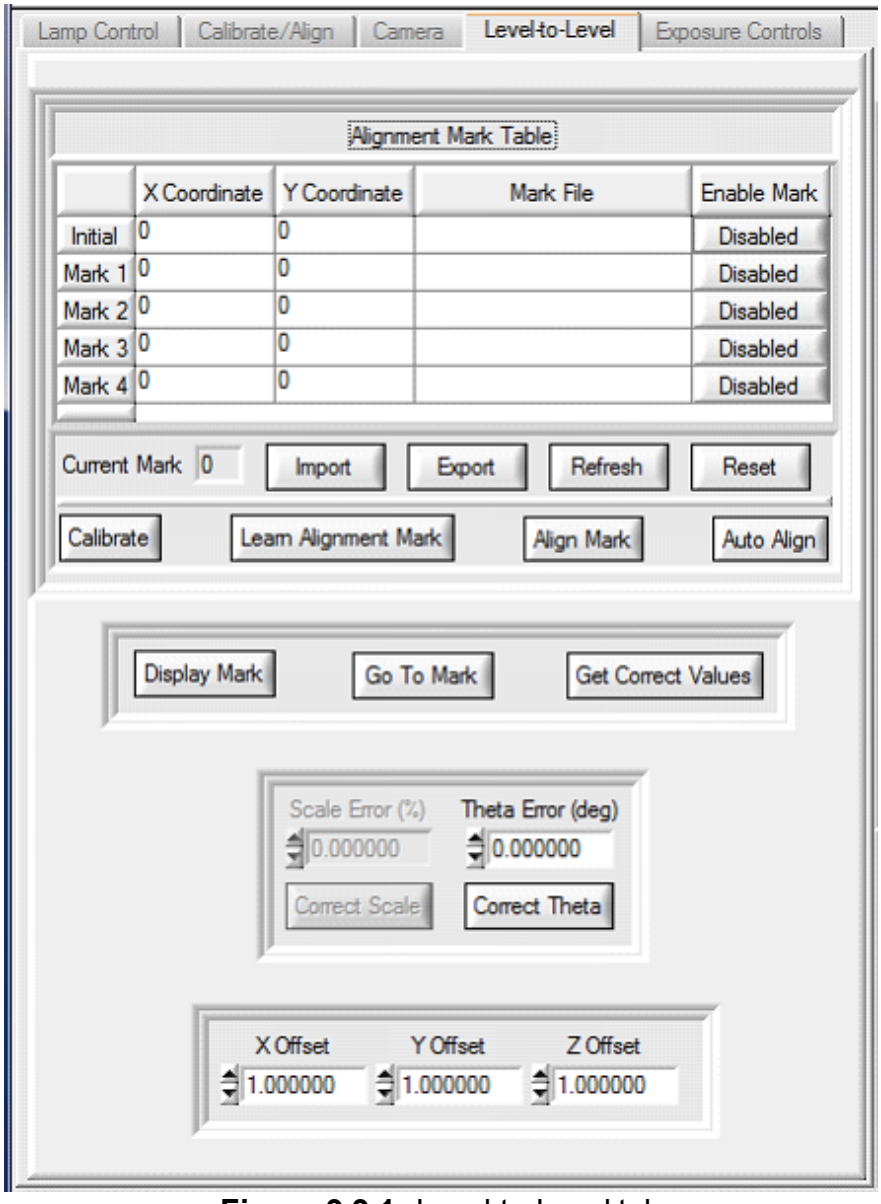


Figure 9.9.1: Level-to-Level tab

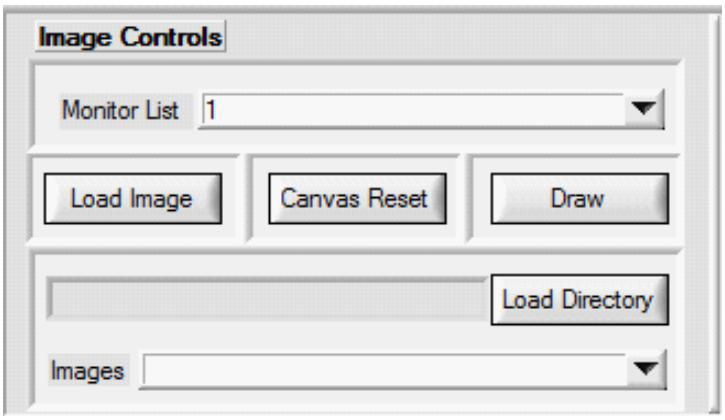


Figure 9.9.2: Image Controls

Steps for completing a multiple level automatic alignment

1. The "Alignment Mark Table" (*see Figure 9.9.1*) will need to be populated. To do this, the desired artwork (Image or Directory) must be loaded. For single images, use the "Load Image" control (*see Figure 9.9.2*). For multiple images use the "Load Directory" control (*see Figure 9.9.2*). Next, input the x and y pixel coordinates of up to four, but at least two alignment mark locations into the "Alignment Mark Table" (these coordinates can be found in a drawing program such as Paint). If a multiple image directory is loaded, use the "Images" ring control (*see Figure 9.9.2*) to display the image that the coordinates reference and click "Disabled" of the corresponding mark located in the "Alignment Mark Table." Upon clicking "Disabled," the "Mark File" cell will be populated with the image currently loaded in the "Images" control ring and the alignment mark will now be enabled. For single images ensure the proper artwork is loaded before clicking "Disabled." By clicking "Disabled," this label will now show "Enabled." This will enable the desired alignment mark for use with the auto alignment routine. "Refresh" (*see Figure 9.9.1*) will populate the initial coordinate location. This control saves the start position, so it should only be pressed when the initial exposure image is loaded, and the stage/substrate is located at the start position. This coordinate location will represent the start of the exposure both for the substrate location and the first digital mask exposure field. Once the alignment mark table has been completed the values can be saved for future use by clicking "Export" (*see Figure 9.9.1*) and saving the file as a .txt file. Likewise if a .txt file has already been created, the alignment mark table can be automatically populated by clicking "Import" (*see Figure 9.9.1*) and selecting the appropriate file. If an error is made populating the Alignment Mark Table, "Reset" (*see Figure 9.9.1*) will restore it to its default settings.

2. "X Offset," "Y Offset," and "Z Offset" (*see Figure 9.9.1*) need to be set. X Offset and Y Offset will most likely be set to 0.0mm. These values relate to the variation between the x and y location of the actual image and the camera view image. Most likely Z Offset will have to be altered. To find the correct Z Offset, focus the camera on the projected image by adjusting the Z stage height or using the "Focus" routine and record the Z encoder values. Next, focus the camera on the substrate by adjusting the Z stage height and record the Z encoder values. Set

"Z Offset" to, the image focus Z values minus the substrate focus Z values and return the Z height to its previous height.

3. Center and orient the substrate as close as possible to the original location on the substrate chuck and activate vacuum hold on the substrate chuck. The theta error should not exceed one degree.

4. If not already completed, run the "Auto Expose Setup" located in the "Exposure Controls" tab. An overview of the "Auto Expose Setup" feature can be found in the SF-100 Users Manual.

5. Using the camera controls ensure the camera's settings are properly adjusted for the substrate used. The image should not appear to dim or saturated.

6. Next the camera needs to be calibrated. Note: If this procedure has already been completed there is no need to do it again, unless a change in the optical setup has taken place. Click on "Calibration" (*see Figure *9.9.1*) and outline the calibration grid (*see Figure 9.9.3*).

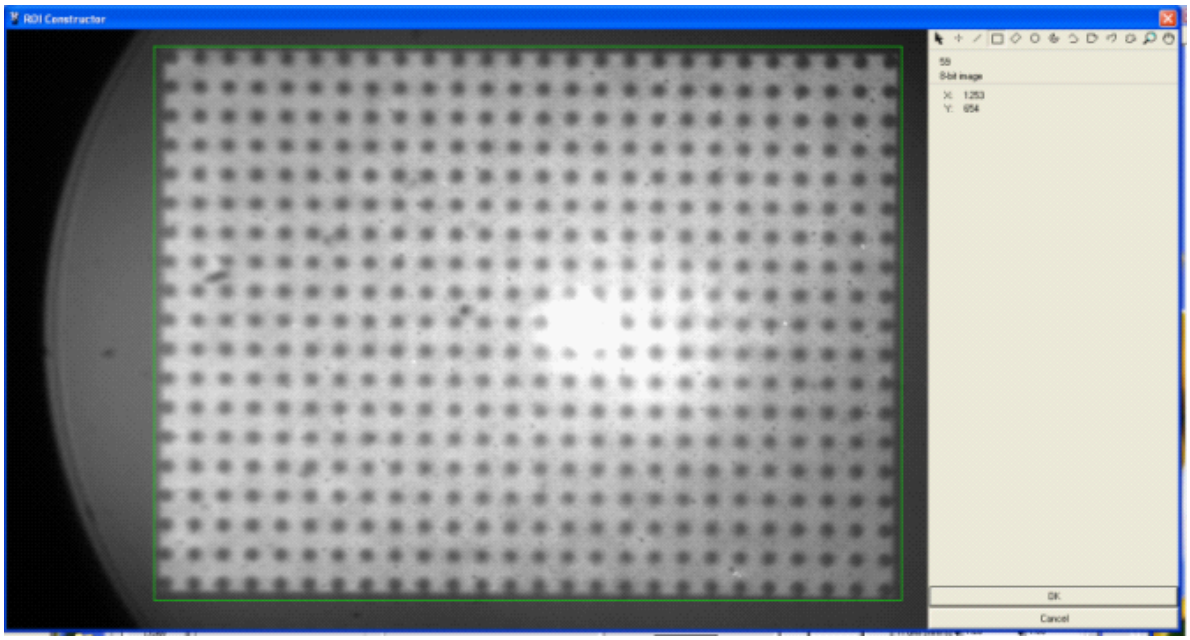


Figure 9.9.3: Calibration grid for camera

To close the window, click "OK." If there was an error during the calibration process it will be displayed on the "Message Window;" if any errors do occur please re-run the calibration upon fixing the described error (The most common error is due to improper camera settings.)

7. The next step is to teach the system the alignment marks. Note: If this procedure has been previously completed for the desired mark, there is no need to do it again. To teach the system the alignment marks being used, click “Learn Alignment Mark” (*see Figure 9.9.1*) while the alignment mark is being displayed in the artwork and highlight the desired feature (*see Figure 9.9.4*).

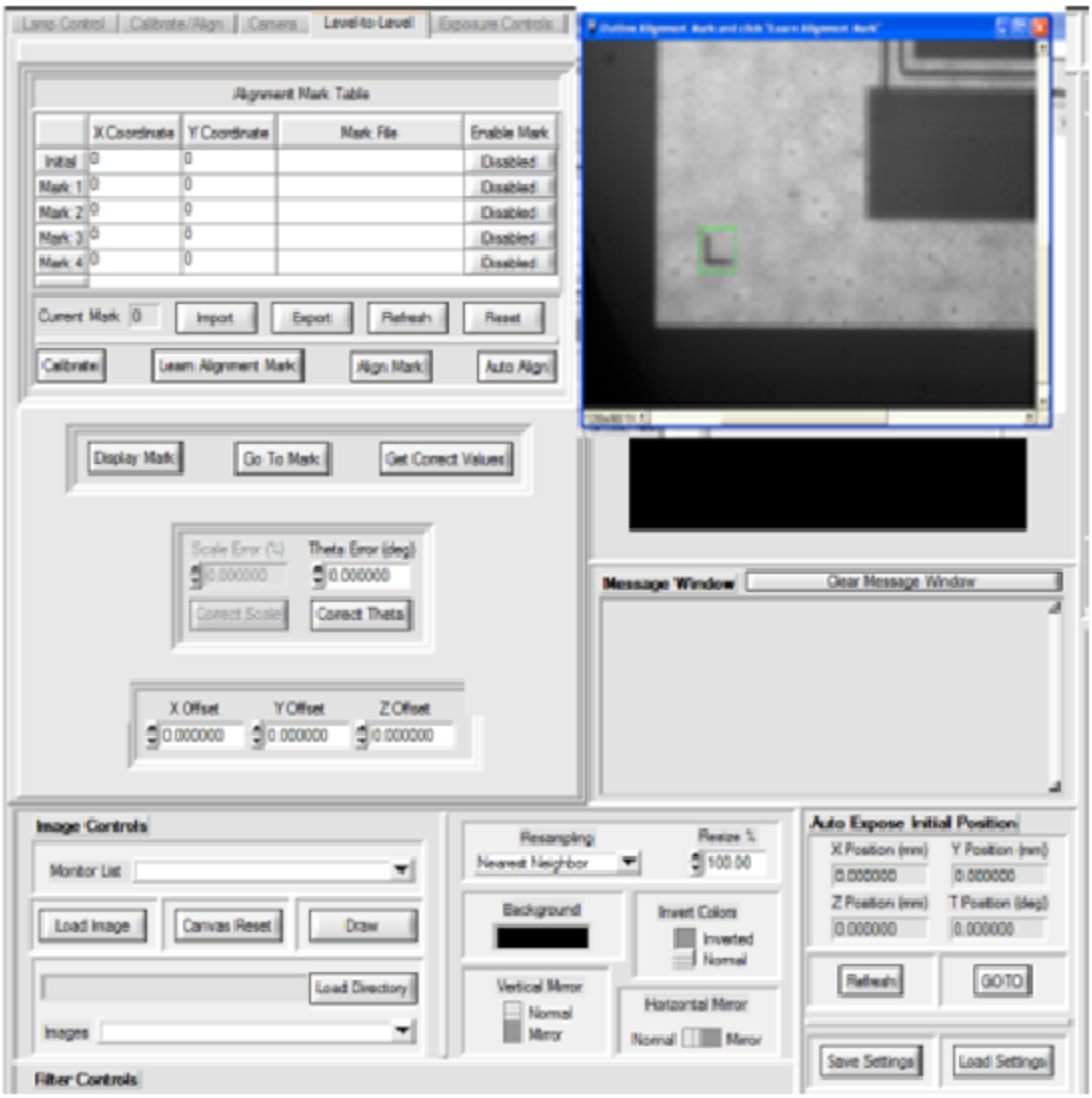


Figure 9.9.4: Learn Alignment Mark Window

When the alignment mark is selected in the Learn Alignment Mark popup, click “Learn Alignment Mark” again to close the window. If there was an error during the calibration process it will be displayed on the “Message Window;” if any errors do occur please re-run the calibration upon fixing the described error (The most common error is due to improper camera settings.)

8. Roughly align the initial position displayed with the patterned image and click “Refresh”.

9. Click “Auto Align” to start the auto alignment process. “Auto Alignment Completed” will be displayed in the Message Window box when the process has been completed. If multiple messages reading “Alignment Mark not found” appear in the Message Window, the auto alignment process might not have been successful. If the substrate is in fact not aligned, please check the camera settings (gain and shutter speed) focus, and retry.

   Note: This process will take several minutes to complete.

Steps for completing a multiple level manual alignment

Note: Above steps must be completed before continuing except the camera calibration (step 6) and learn alignment mark (step 7).

1. Select “Mark 1” then “Display Mark” then “Go To Mark.” Wait for the stage movement to be completed.
   Note: The Camera View CANNOT be active during stage moves!

2. Verify “Direct Control” is ON before proceeding. Move the stage to align the projected image Mark 1 with the equivalent mark on your substrate.
   Note: The Z stage might need to be adjusted the “Z Offset” amount to achieve optimal focus.

3. Select “Mark 2”, “Display Mark”, then “Go To Mark.” Wait for the stage movement to be completed.

4. Move the stage and align the projected image Mark 2 with the equivalent mark on your substrate.

5. Select “Get Corrected Values” then “Calculate Offsets”.

6. If projected and substrate marks are not aligned, select “Correct Theta.”

7. After Correcting for Theta, verify marks are still aligned. If not, move the stage to re-align the marks.

8. Select “Mark 3” then “Display Mark” then “Go To Mark”. Wait for the stage movement to be

completed.

9. If projected and substrate marks are aligned, alignment is complete and no further action is required.

10. If projected and substrate marks are not aligned, select “Correct Theta.”

11. After Correcting for Theta, verify marks are still aligned. If not, move the stage to re-align the marks.

12. To verify projected and substrate marks are aligned, select “Mark 4”, “Display Mark”, and then “Go To Mark”. The projected and substrate marks should be aligned. If not repeat this process as needed.

13. Click on “Initial”, “Display Mark”, then “Go to Mark” to return to Auto Start Position.

14. Proceed with auto exposure.

9.10 Performing an Exposure Matrix

1. After loading the desired artwork and setting the correct exposure time, navigate to "Options" then "Exposure Matrix" (*see Figure 9.10.1*) to open the “Exposure Matrix Setup” panel.

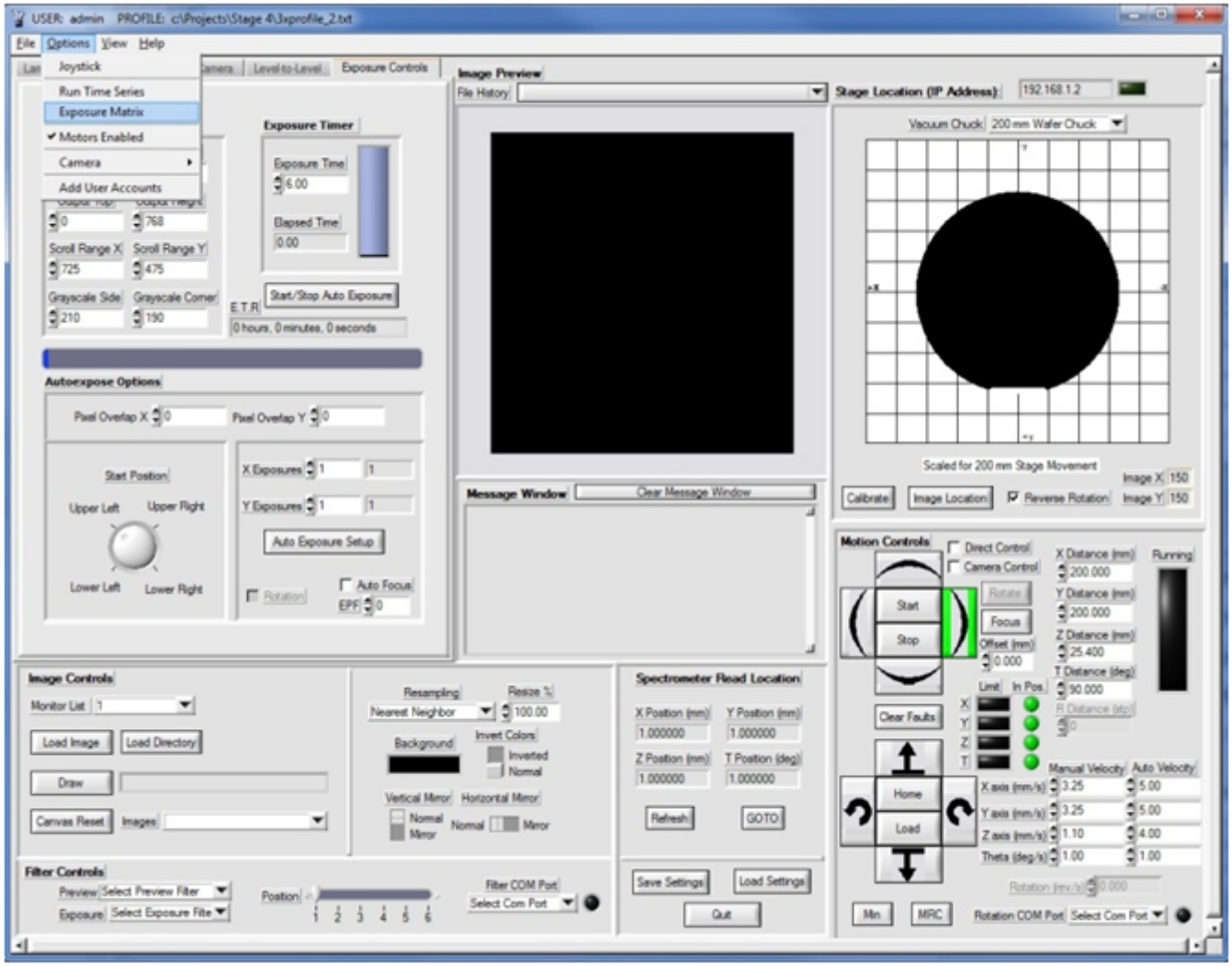


Figure 9.10.1: Screen Capture showing the location of the Exposure Matrix option

2. Following the displayed procedure (*see Figure 9.10.2*), the “Desired Exposure Array”, “Delta X”, and “Delta Y” need to be populated.

   Note: the coordinate system is rotated 90 degrees. When the controls are populated, click “Start / Stop Exposure Matrix” only once to start the process and wait for a popup displaying “Done” to alert that the process is finished.

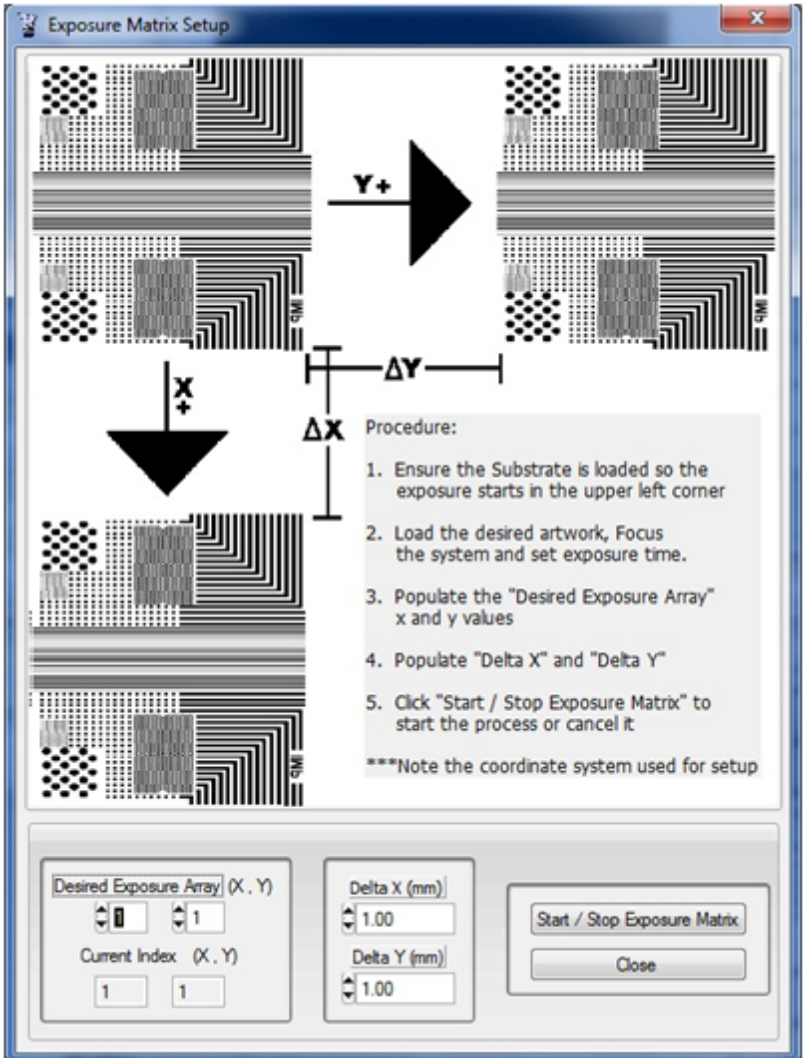


Figure 9.10.2: Exposure Matrix Setup window

Note: If during this process, it needs to be canceled, click “Start / Stop Exposure Matrix”one time and a warning popup (Figure 3) will be displayed. Clicking “Yes” will abort the current process. If “Yes” is clicked, an additional popup will be displayed informing the user that the process will be aborted after the current exposure has been completed (*see Figure 9.10.4*). Click “OK” and wait for the “Done” prompt to be displayed.

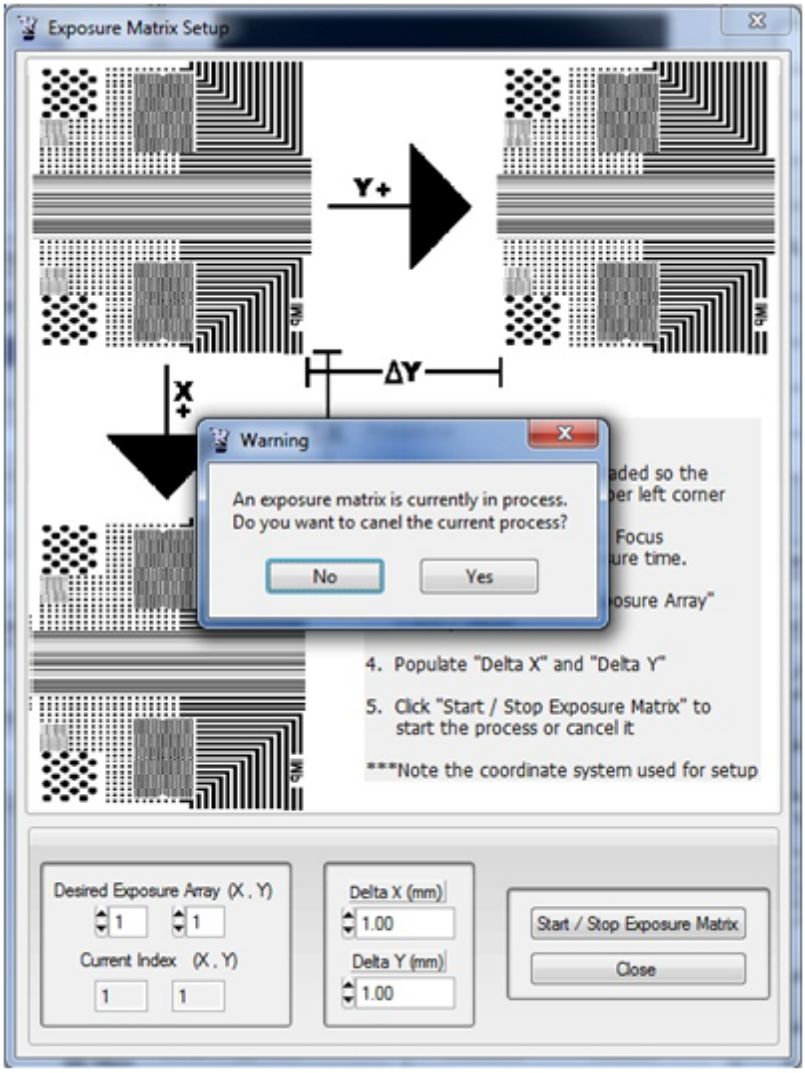


Figure 9.10.3: Popup that displays when canceling the exposure

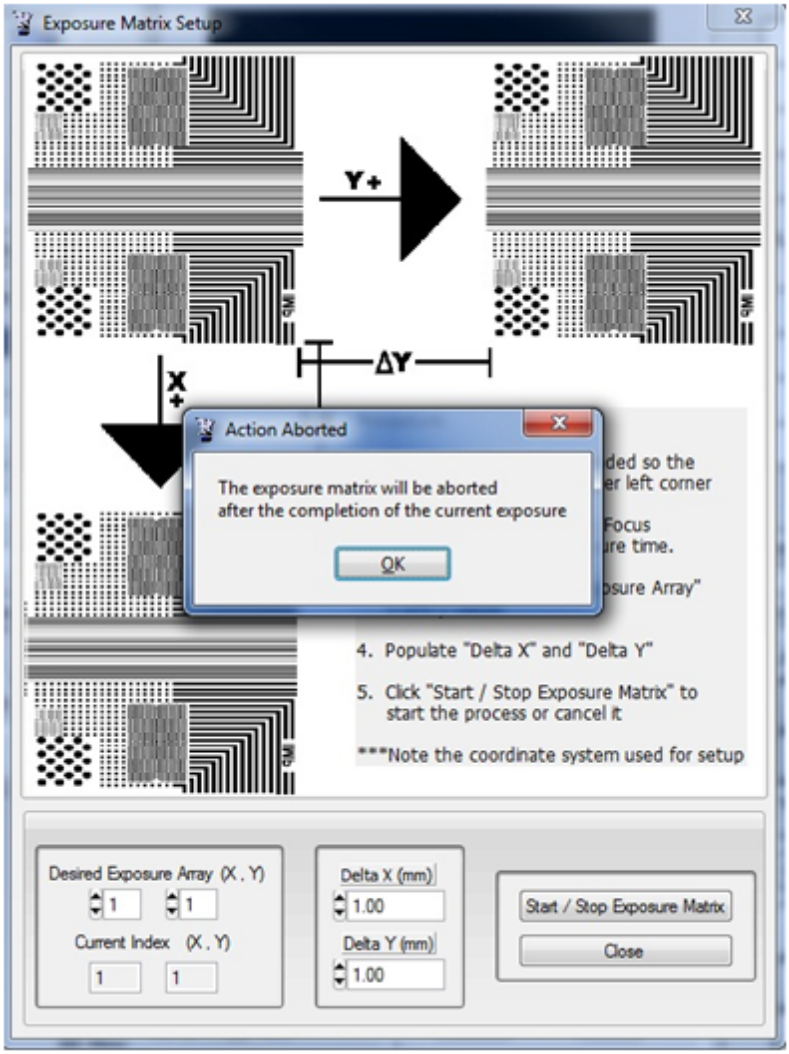


Figure 9.10.4: Popup that displays after confirming exposure cancellation

9.11 Executing a Time/Height Series

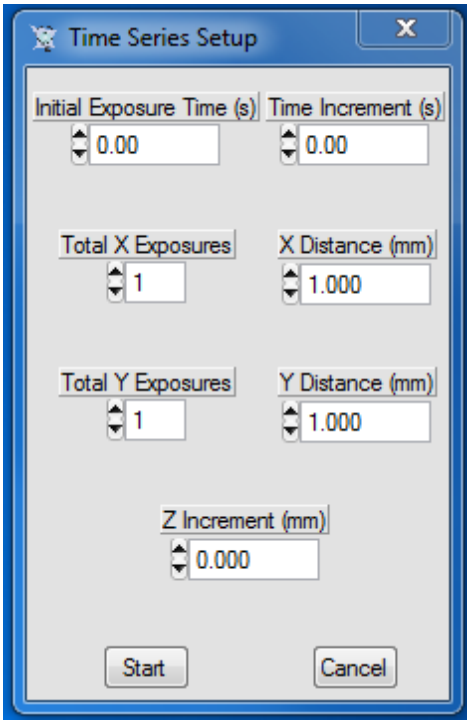


Figure 9.11.1: Time/Height Series Options Window

Time Series

1. Place a coated slide on the chuck, if the chuck is supplied with a vacuum feature turn on the vacuum pump to ensure that the slide does not move.

2. Bring the image manually into focus, then using the "focus" button (located in the motion controls section) start the autofocus routine.

3. Once the image is in focus, the next step is to open the time series window. Do this by clicking on the "Options" menu and selecting "Run Time Series". The window in *Figure 9.11.1* will popup.

4. The next step is to populate all the fields in the window. For an explanation of each field refer to "Time/Height Series".

5. For a time series the "Z increment" must be set to 0.000.

6. After populating all the fields with the appropriate values, simply press "Start".

Height Series

1. Place a coated slide on the chuck, if the chuck is supplied with a vacuum feature turn on the vacuum pump to ensure that the slide does not move.

2. Bring the image manually into focus, then using the "focus" button (located in the motion controls section) start the autofocus routine.

3. Once the image is in focus, the next step is to open the time series window. Do this by clicking on the "Options" menu and selecting "Run Time Series". The window in *Figure 9.11.1* will popup.

4. The next step is to populate all the fields in the window. For an explanation of each field refer to "Time/Height Series".

5. For a time series the "Time increment" must be set to 0.00.

6. After populating all the fields with the appropriate values, simply press "Start". *Figure 9.11.2* shows the order that the time series will be exposed.

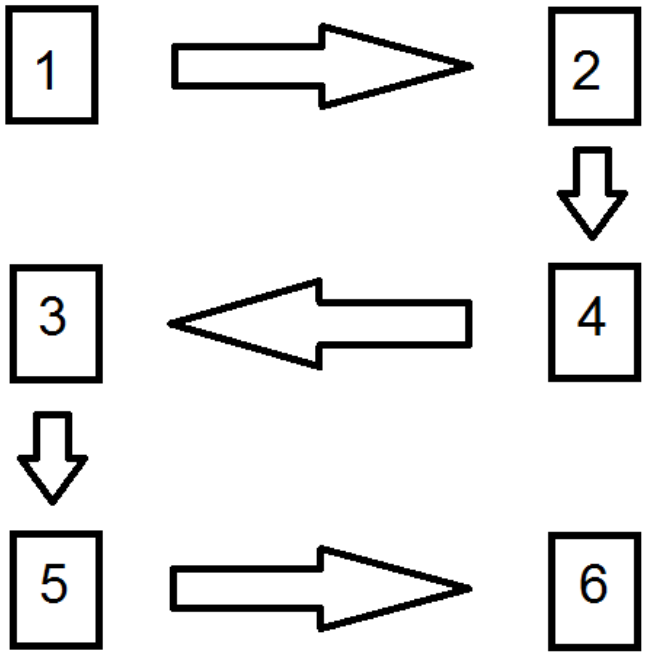


Figure 9.11.2: Image showing stage movement/exposure order

9.12 Restarting a Halted Auto Expose Sequence

To re-start a halted exposure sequence, the X and Y exposure values will have to be adjusted to address only the remaining exposures, possibly more than once.

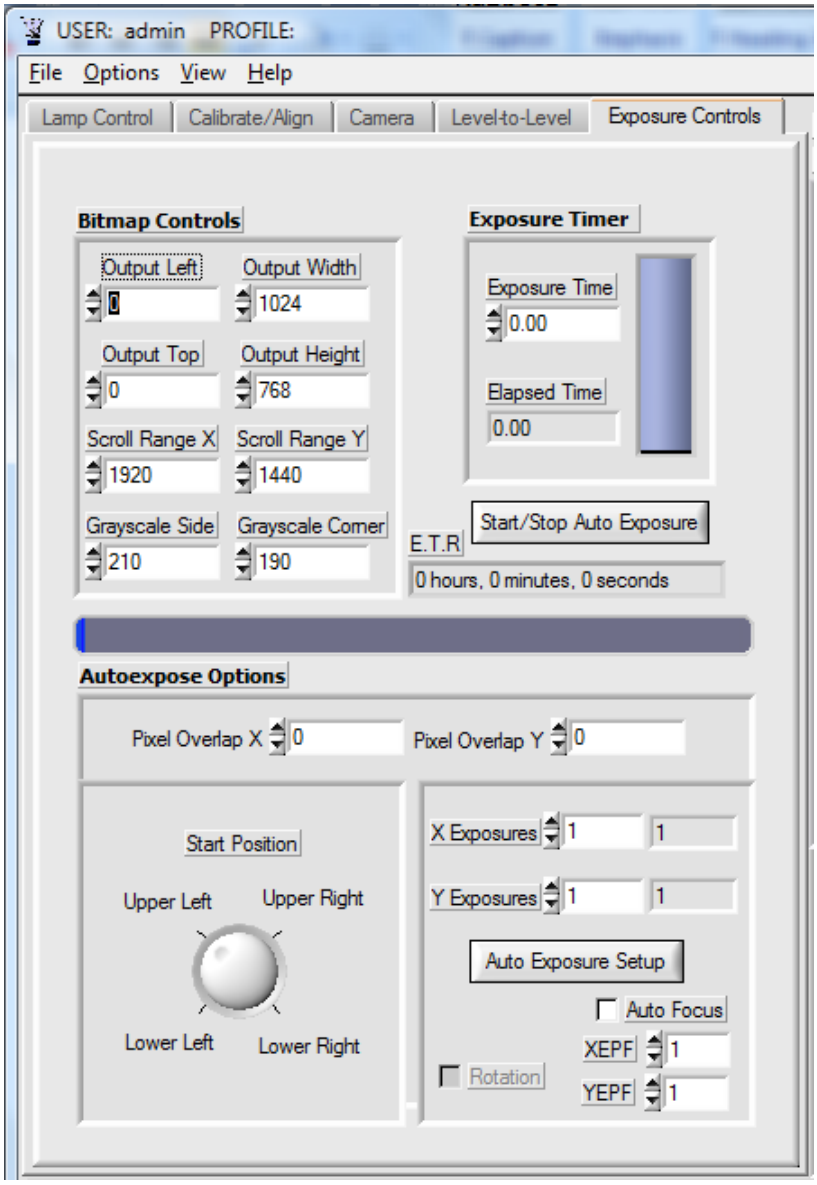


Figure 9.12.1: Exposure Controls Tab

1. First, finish the current row (X-axis) by putting the number of remaining exposures in this row in the “X Exposures box”. If at the “head” of the row, skip to step 7 below.

2. Change the number of “Y Exposures” to “1”.

3. Change the “Start Position” dial to reflect this new *starting* position, if necessary. Remember that the sequence is *away* from the starting position.

4. Then select the “Start/Stop Auto Exposure button”. When done, Auto Exposure will stop at the end of the row.

5. Using the Direction Controls, select the up or down button to move the stage in the Y-direction. If the red frame needs to go down, use the up button (image goes up) and vice versa.

6. Highlight the viewing window and use the up arrow to move the red frame relatively down (image goes up) or vice versa as needed. Now the image and the stages are aligned again in the next row.

7. Once at the “head” of the next row, reset the “X Exposures” and “Y Exposures” windows to represent the full number of remaining exposures for this entire image.

8. Change the “Start Position” dial, if necessary, to represent this new *starting* position, as explained above.

9. Select the “Start/Stop Auto Exposure” and it will finish the remaining exposures and shut off.

9.13 Manual Exposure Frame Manipulation

The first step to manipulate the exposure frame is to Left-click inside the "Image Preview" window (*see Figure 9.13.1*). A green highlighted preview window indicates to the user that the exposure frame can be manually manipulated using the keyboard. Left-clicking anywhere outside the preview window will deactivate manual manipulation of the exposure frame and resume normal key-command functions. Once the frame is highlighted in green, movement of the artwork can be accomplished using the arrow keys on the keyboard (refer to "Image Preview").

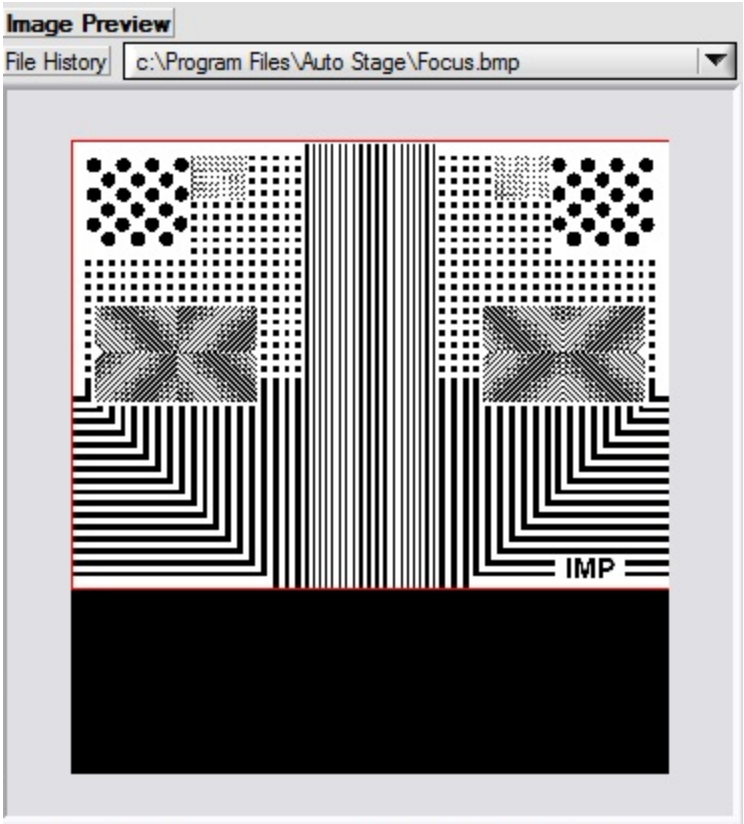


Figure 9.13.1: Image Preview Window

This is useful, for example, if the user wishes to manually expose a white rectangle equal to the dimensions of a full exposure frame. Once the preview window is highlighted in green and the background is changed to white (refer to "Image Controls"), the user can simply use the arrow keys to move the artwork out of the exposure frame so that the exposure frame is all white. When the exposure frame is white the DMD is reflecting all the light onto the substrate.

> Note: The examples below are only useful when an artwork composed of multiple exposure frames is loaded and the "Auto Exposure Setup" has been completed.

Another example of a useful application of this feature is that the user can manually scroll through a large artwork to see where it will be stitched. This leads to an additional feature that can be very useful. The manual frame manipulation can be used to set up the auto exposure so that a critical structure in the artwork is exposed in a single frame, instead of being stitched. After loading the desired artwork, highlight the "Image Preview Window" by clicking it. Notice that as mentioned above you can move through the artwork. Also notice that the red exposure frame moves according to the settings in the "Bitmap Controls" section. In other words it is moving an entire exposure window at a time, less the set overlap.

To change the way the artwork is stitched, simply move the exposure frame as close as possible to the critical structure in the artwork. Then, hit the "Insert" key on the keyboard (the "Insert" key toggles a mode wherein the exposure frame only moves a single pixel at a time). After turning on this mode, the frame can be moved so that the structure is contained in a single exposure frame (assuming the structure will fit). After the frame is set, simply hit the "Insert" key again to toggle back to the normal mode. It is important to scroll through the artwork in the normal mode again to verify that the exposure frame will still cover the entire artwork. In the case that the frame stops short of covering the artwork in the "X" direction, simply add one to the number of "X Exposures" (refer to "Auto Exposure Options"). The same thing can be done if the frame stops short in the "Y" direction, add one to the number of "Y Exposures". Upon verification that the artwork will expose as desired, it is important to manually move the exposure frame back to the starting position (upper left corner of the artwork), then click "Start/Stop Auto Exposure" to start exposing the artwork.

> Note: After manually changing the exposure frame do not click the "Auto Exposure Setup" button again as this will reset the frame to default. The "Auto Exposure Setup" button should be clicked prior to the exposure frame manipulation.

9.14 Loading Multiple Images

Sometimes it is necessary to split a large artwork into smaller images that can be processed by the program (refer to "Design Guidelines" and "BMP Parser").

1. A bitmap directory can be loaded via the “Load Directory” control, located in the Image Controls section of the *Auto Stage*™ Program.

2. Clicking on the control will display a directory selection popup (*see Figure 1*). Navigate to the directory containing the bitmap files and click “Done.”

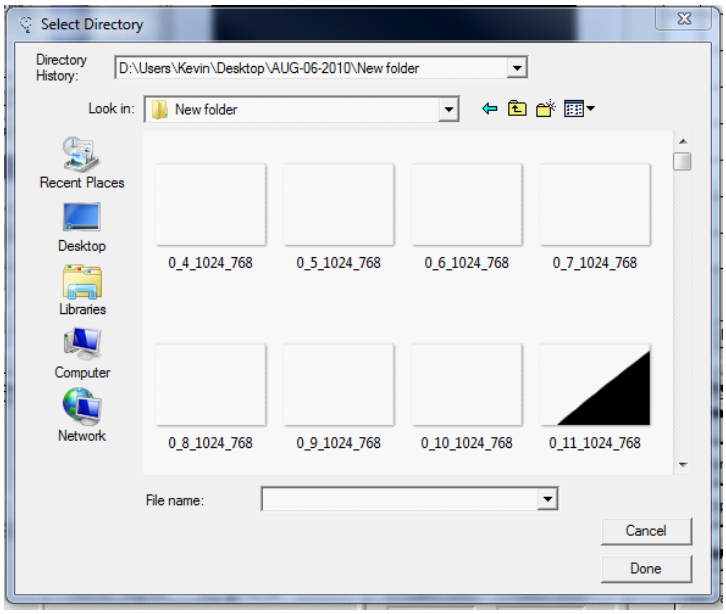


Figure 7.2.3.2.1: Load Directory

3. The next step in the Auto Exposure process is to click on the “Auto Exposure Setup” control, located in the Exposure Controls Tab; this will determine the number of X Exposures and Y Exposures needed for the Auto Exposure process. The Auto Exposure process can be continued as normal.

INTELLIGENT
MICRO PATTERNING, LLC

Part X

10 Maintenance

In order to ensure outstanding operation of the system, the following routine maintenance procedures must be utilized at the time intervals indicated. Please take note of all warnings and cautions associated with each maintenance procedure before performing them. Also, read through the respective procedure beforehand and make sure that it is within your ability.

10.1 Cable, Connector, and Enclosure Maintenance

- Ensure that all connectors and cables are free of kinks, tears, or cuts on a periodic basis.

- Always use care when removing or replacing the unit cover. Avoid disconnecting, pinching, or breaking the wires connecting the cover to the main body.

- Wipe off the SF-100 enclosure as needed using a dry, soft cloth. Do not use solvents/ cleaners for this, as these chemicals may destroy the finish on the system.

10.2 Lamp Maintenance

- To maximize light source life, the source should be turned off when the system is not in use.
  - Turn the light source on/off using the “Lamp Power” button in the “Lamp Control” tab.
  - When the light source is turned on, it will require 30 minutes to stabilize before using the system.

- The light source should be replaced on or before it reaches the maximum of 1000 hours. This is the longest time that a lamp should be run. Critical processes may require that the light source be changed more frequently. See “Replacing the Lamp” in the next section for lamp replacement instructions.

- Check the exposure energy at the substrate surface using a handheld exposure meter on a regular basis. If you do not have an exposure meter, Intelligent Micro Patterning can make a

recommendation or supply you with one for a nominal charge. Contact us for more information and a quote.

10.3 Replacing the Lamp

1. Turn off the lamp.

2. Turn off the SF-100 Unit using the switch on the inlet power module and disconnect the power cable from the electrical outlet.

3. Wait a minimum of 60 minutes for the lamp to cool prior to continuing.

4. Remove the (5) five UNC # 6-32 flathead screws holding the lamp access panel in place on the back of the unit (*see Figure 10.3.1*).

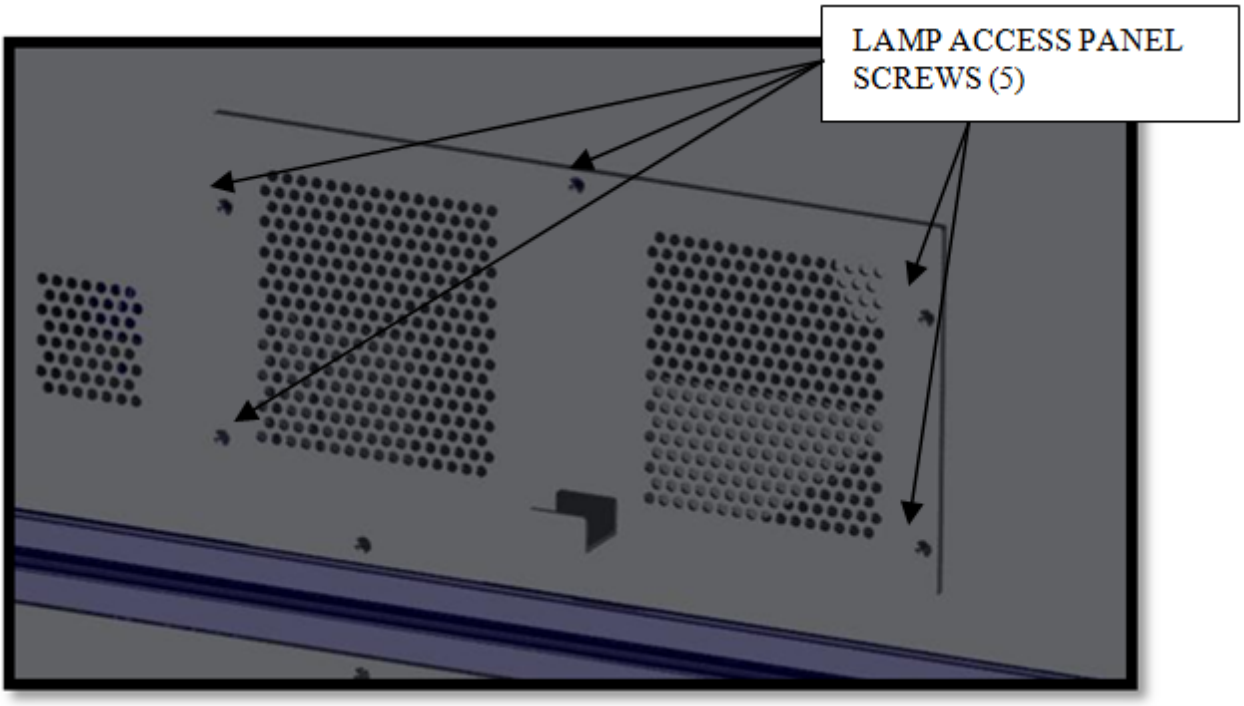


Figure 10.3.1: Rear View of SF-100 Maskless Photolithography System

5. Remove the lamp access panel from the SF-100 Unit.

6. Disconnect the lamp fan by gently separating the mating connectors.

7. Using a Phillips screwdriver, carefully remove the (4) four UNC #4-40 Phillips pan head retaining screws holding the lamp fan cage in place at the beginning of the optical path (*see Figure 10.3.2*).

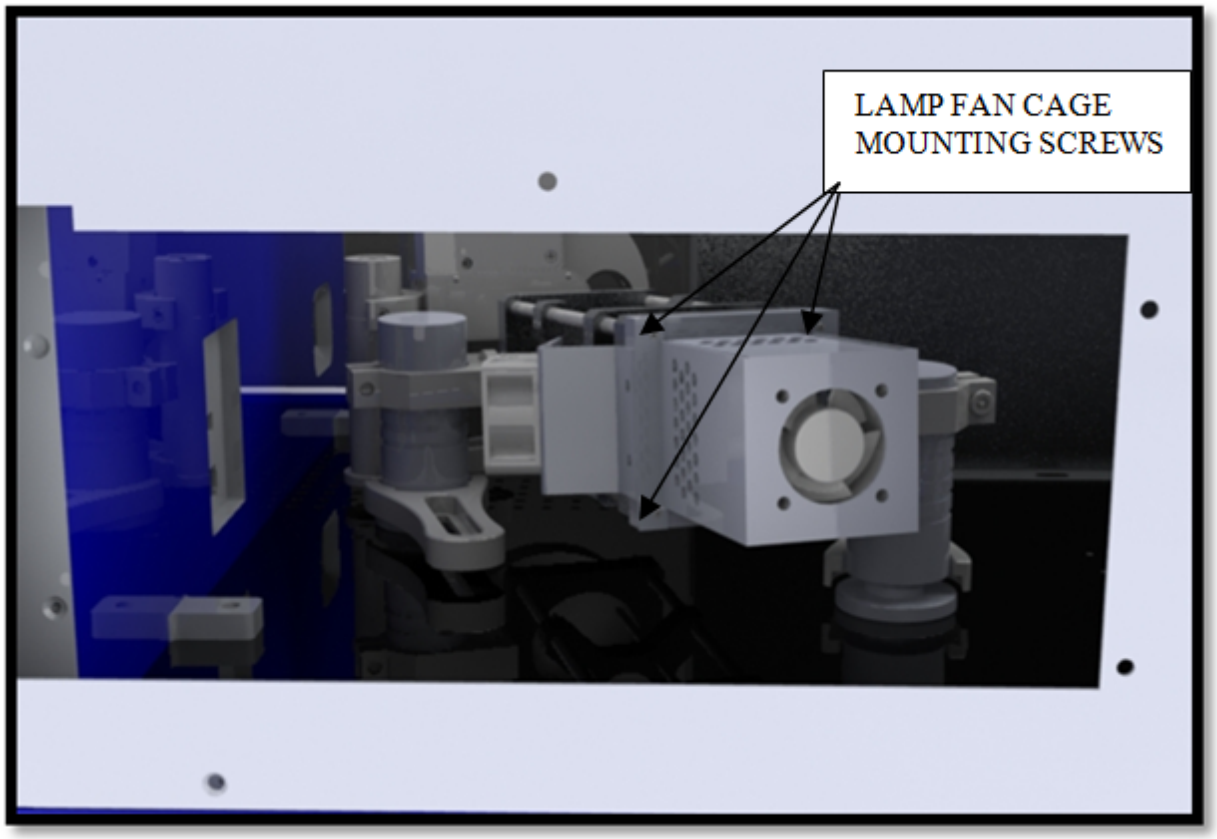


Figure 10.3.2: Internal Rear View of Lamp Assembly

8. Carefully remove the lamp fan cage assembly from the rear of the system.

9. Disconnect the old lamp by gently separating the lamp power connectors.

10. Using lint-free gloves to prevent getting fingerprints on the lamp, remove the old lamp assembly and replace it with a new lamp assembly. Do not forget to reconnect the lamp power connectors.

11. Replace the lamp fan cage assembly, ensuring the lamp power cable is positioned in the slot at the bottom. Secure the fan assembly to the rear of the lamp assembly using the (4) four UNC # 4-40 Phillips pan head screws removed earlier.

12. Reconnect the lamp fan mating connectors.

13. Replace the lamp access panel onto the SF-100 Unit using the original (5) five screws that hold the panel in place.

14. Turn on the SF-100 Unit using the switch located on the inlet power module at the rear of the unit.

15. Reset the lamp timer by accessing the "Lamp Control" tab in the *Auto Stage*™ program (*see Figure 10.3.3*).

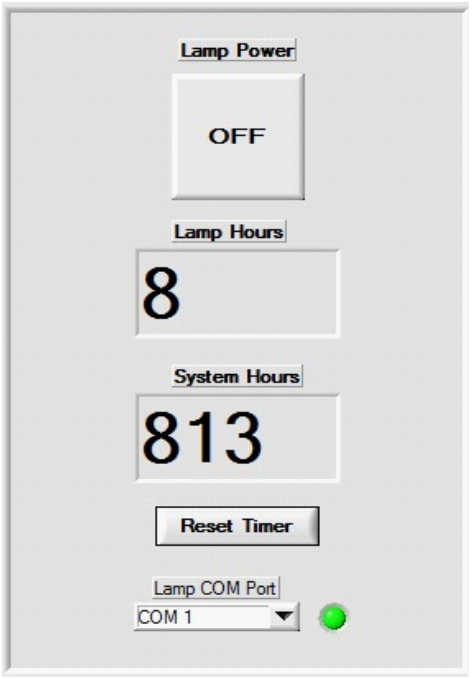


Figure 10.3.3: Reset Timer button in Lamp Control

10.4 Replacing the UV Filters inside the Filter Wheel

Use caution when working inside (and around) the light source. Direct eye exposure with high power optical energy can cause permanent eye damage. When working on the equipment near the light source or any area that may be exposed to this optical energy, it is recommended that you always wear approved safety goggles that provide protection from ultraviolet light.

1. Turn off the lamp.

2. Turn off the SF-100 Unit using the switch on the inlet power module at the rear of the unit.

3. Disconnect the SF-100 Unit main power cable located on the inlet power module at the rear of the unit, from the electrical outlet.

4. With the front panel open, disconnect the power and USB cable connected on the top of the filter wheel.

5. Using an Allen wrench, remove the screw holding the clamp on the Filter Wheel post, and slide out Filter Wheel assembly (*see Figure 10.4.1*).

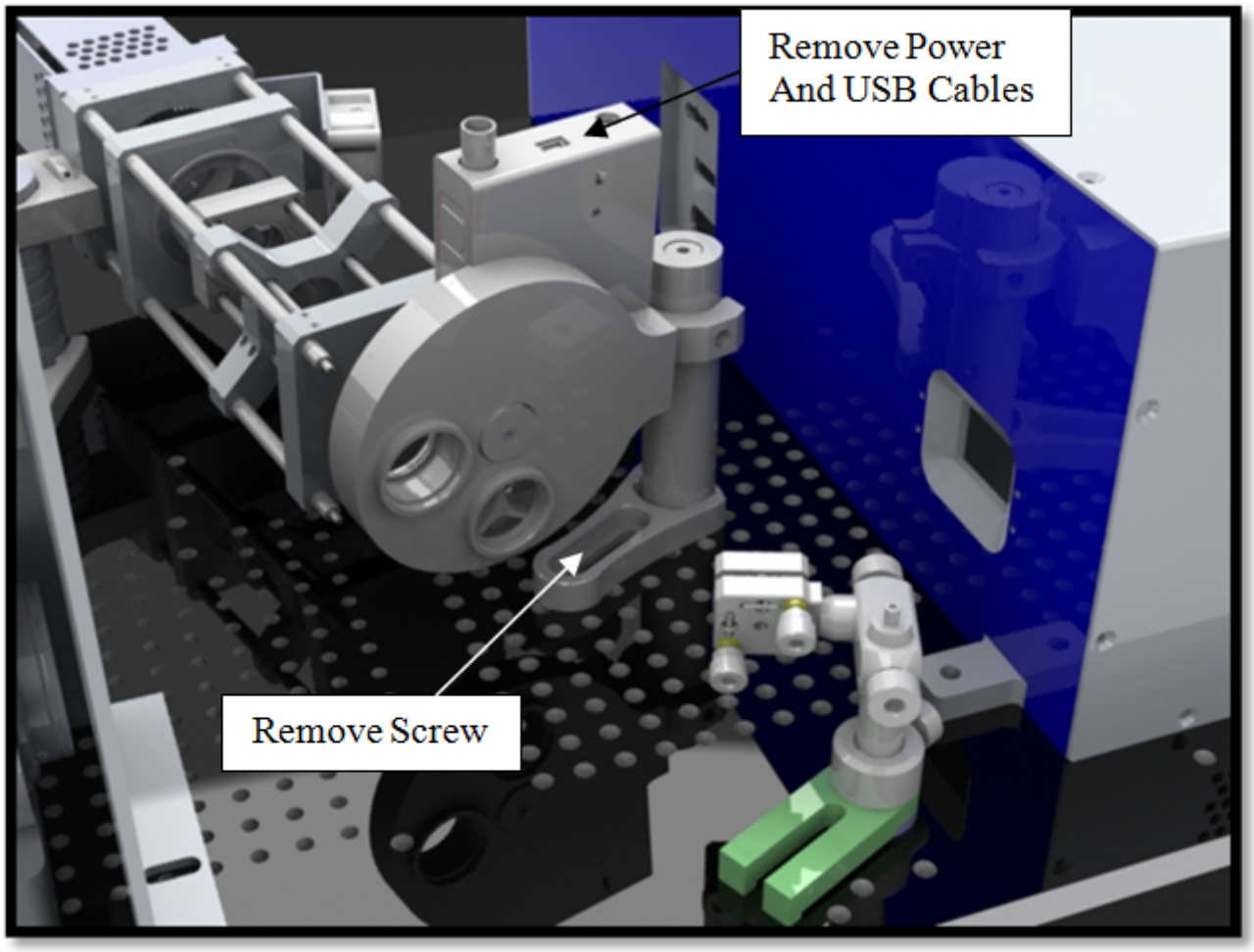


Figure 10.4.1: Filter Wheel Assembly Replacement or Change

6. Using lint free gloves or being careful not to touch the filters, remove the three socket screws on the back side (*see Figure 10.4.2*) securing the UV Filters inside the Filter Wheel.

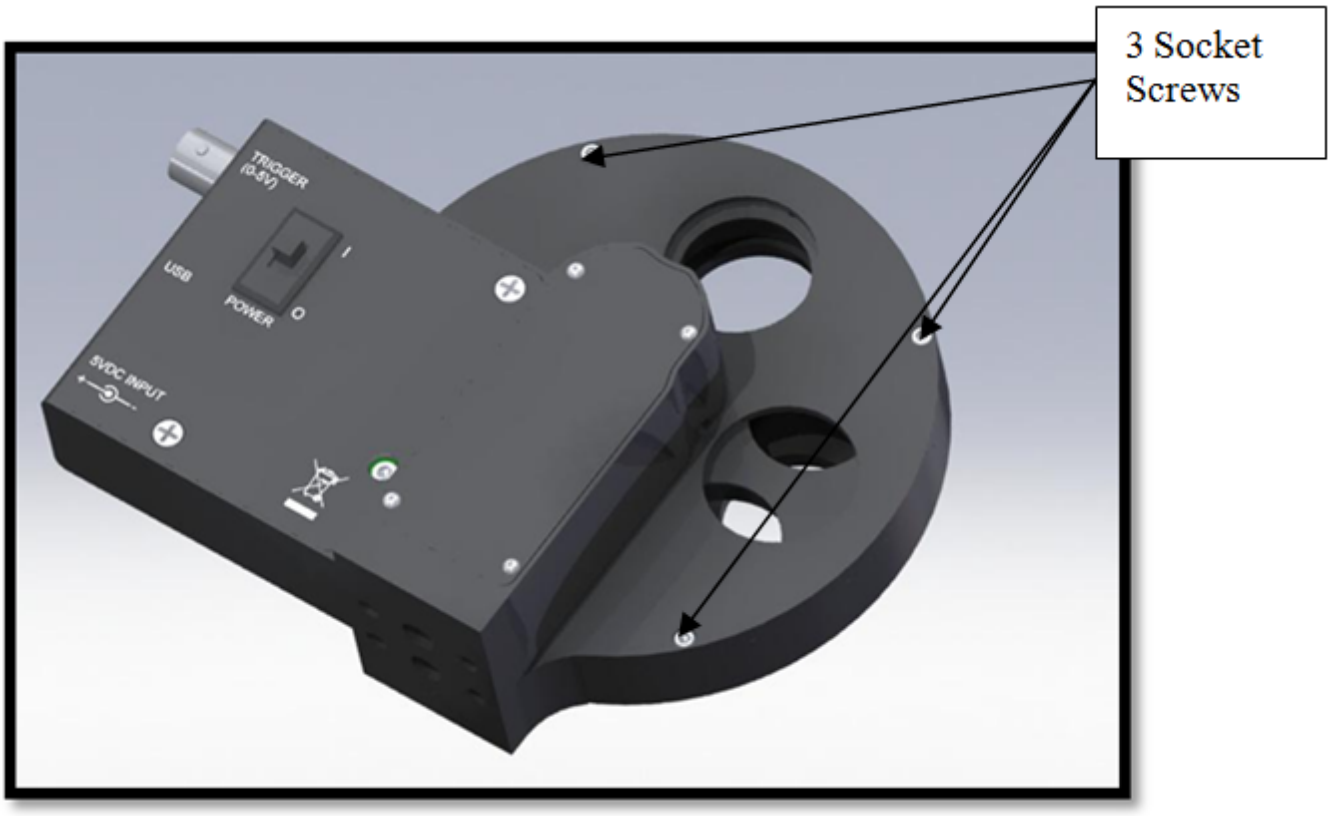


Figure 10.4.2: UV Filter Assembly Replacement

7. Lift the Filter Wheel cover and make sure the filters are secure.

8. Make sure filters are placed in the correct position, so that the light from the lamp hits the correct side of the lens.

9. Replace the system cover and all screws.

10. Reconnect power to the Filter Wheel and the SF-100 Unit. Reconnect the Filter Wheel to the correct COM port in the *Auto Stage*™ Program. The Filter wheel should move to Filter 1.

11. Turn on the system Lamp.

12. Make sure you have UV protective glasses on.

13. Slide the post back into the mounting clamp and slightly tighten so that the filter wheel can still

be moved.

14. With the light on, move the filter wheel as close to the optic train as possible (see *Figure 10.4.3*).

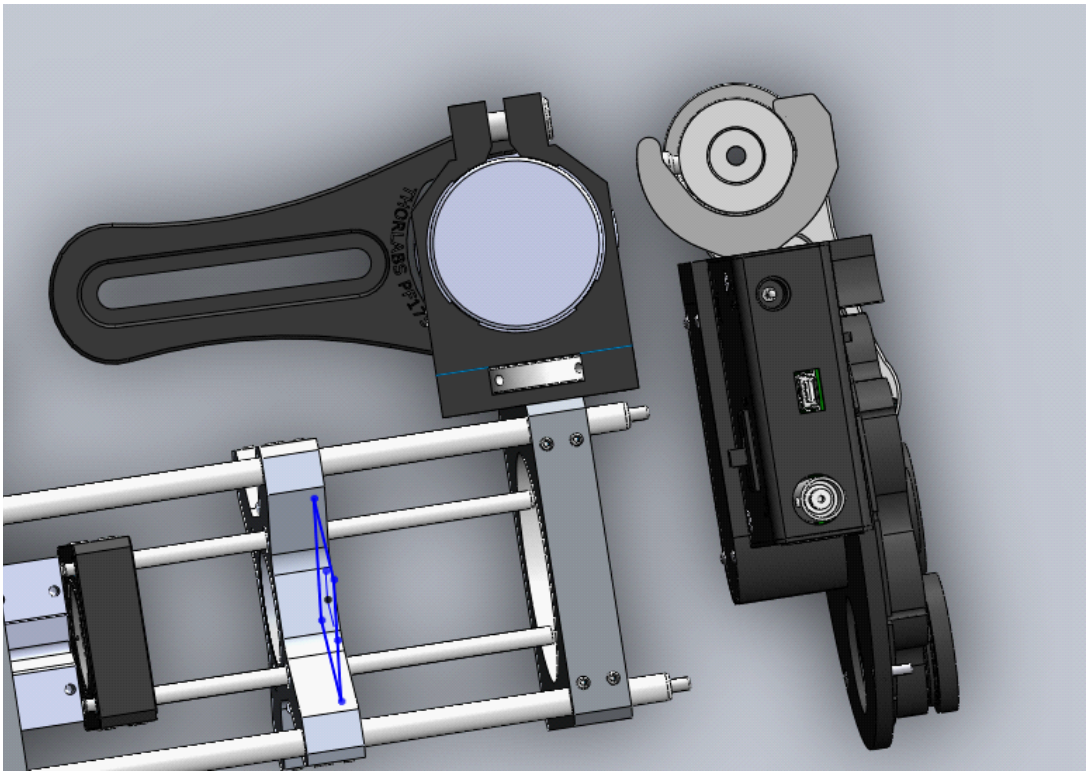


Figure 10.4.3: Filter Wheel Alignment

15. Use the reflection of the light to help center the position of the Filter Wheel. You should see a square of light reflecting back on the optic train. Center this square of light to the center of the optic train (see *Figure 10.4.4*)

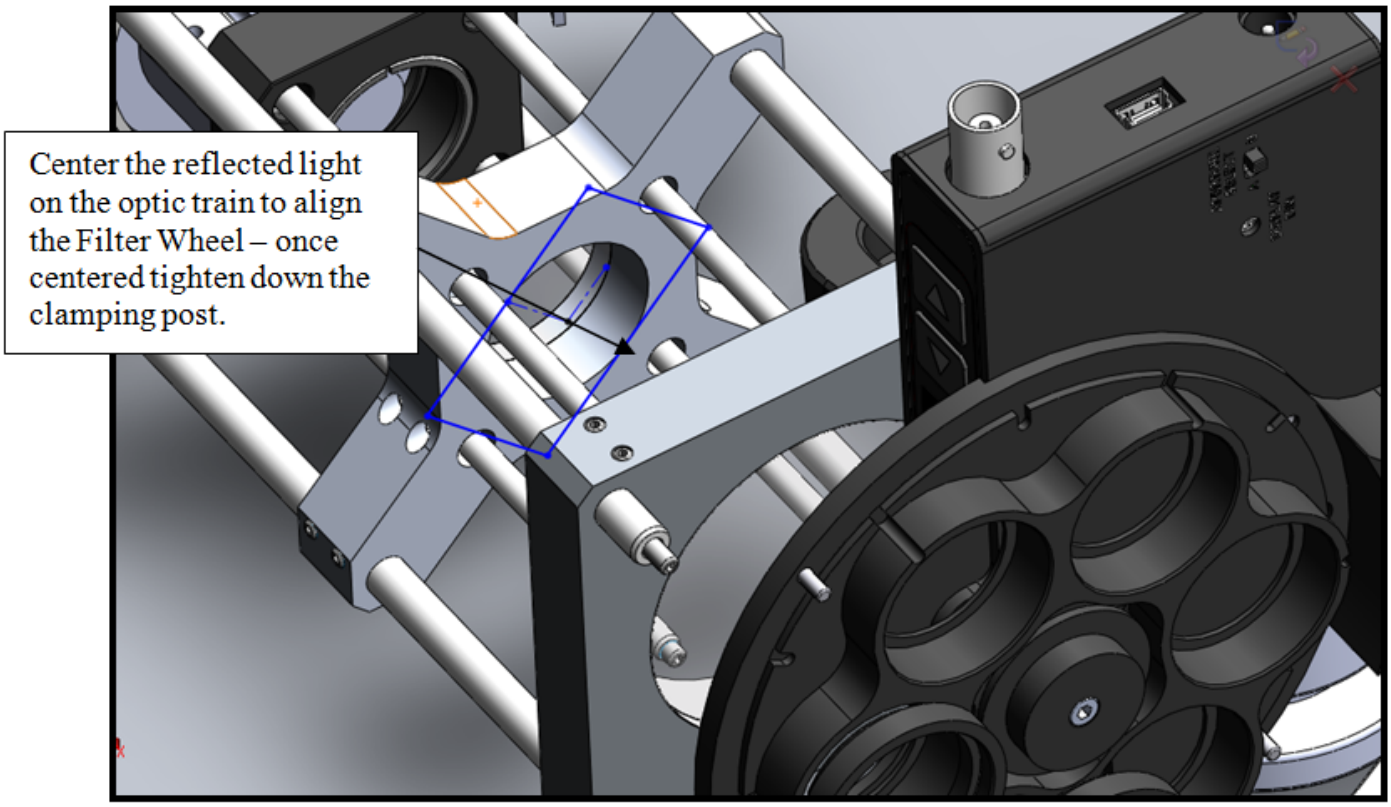


Figure 10.4.4: Filter Wheel Alignment

16. Once the Filter Wheel is in position tighten down the clamping post with the socket screw. The system may need to be tuned to check and see if the stage is still aligned to the optics.

10.5 Optical Component Maintenance

WARNING: Use of flammable materials near heat or electricity can cause fire or explosion. Ensure power is disconnected and all surfaces are cool before cleaning.

If the SF-100 Unit is not used in a clean room environment, the lenses and mirrors may become dirty and require cleaning. If necessary, lens paper with methanol or lens cleaning solution may be used to clean the lenses. To effectively clean the lenses internal to the *Smart Filter*™ light path, they must be removed from the system. Please contact Intelligent Micro Patterning for assistance in removal, cleaning and replacement of these components if necessary.

10.6 Lubrication of Automated Stage

- This procedure shall be performed on a strict 6-months basis to ensure that accuracy, repeatability and resolution are maintained within IMP and stage manufacturer's specification tolerance.

- If conditions of service warrant (high usage, spills, suspended particulates, dirt or vapors are common, etc.), this frequency may need to be increased.

- Included in the documentation package will be stage manuals from the stage manufacturer.

- Please find the corresponding manual pages relating to lubrication and follow the cleaning and lubricating process for each of the four axes.

- Each manufacturer has different requirements, lubricants, and procedures. It is essential that they be followed explicitly.

10.7 Replacing the Smart Filter

WARNING: Opening the *Smart Filter*™ will void your warranty.

1. Turn off the lamp.

2. Turn off the SF-100 Unit using the switch on the inlet power module at the rear of the unit.

3. Disconnect the SF-100 Unit's main power cable located on the inlet power module at the rear of the unit, from the electrical outlet.

4. Using a Phillips screwdriver, remove the screws holding the system cover in place.

5. Carefully remove the system cover, making certain you do not damage the cables connecting the cover to the SF-100 body. You are not required to disconnect the cover cables.

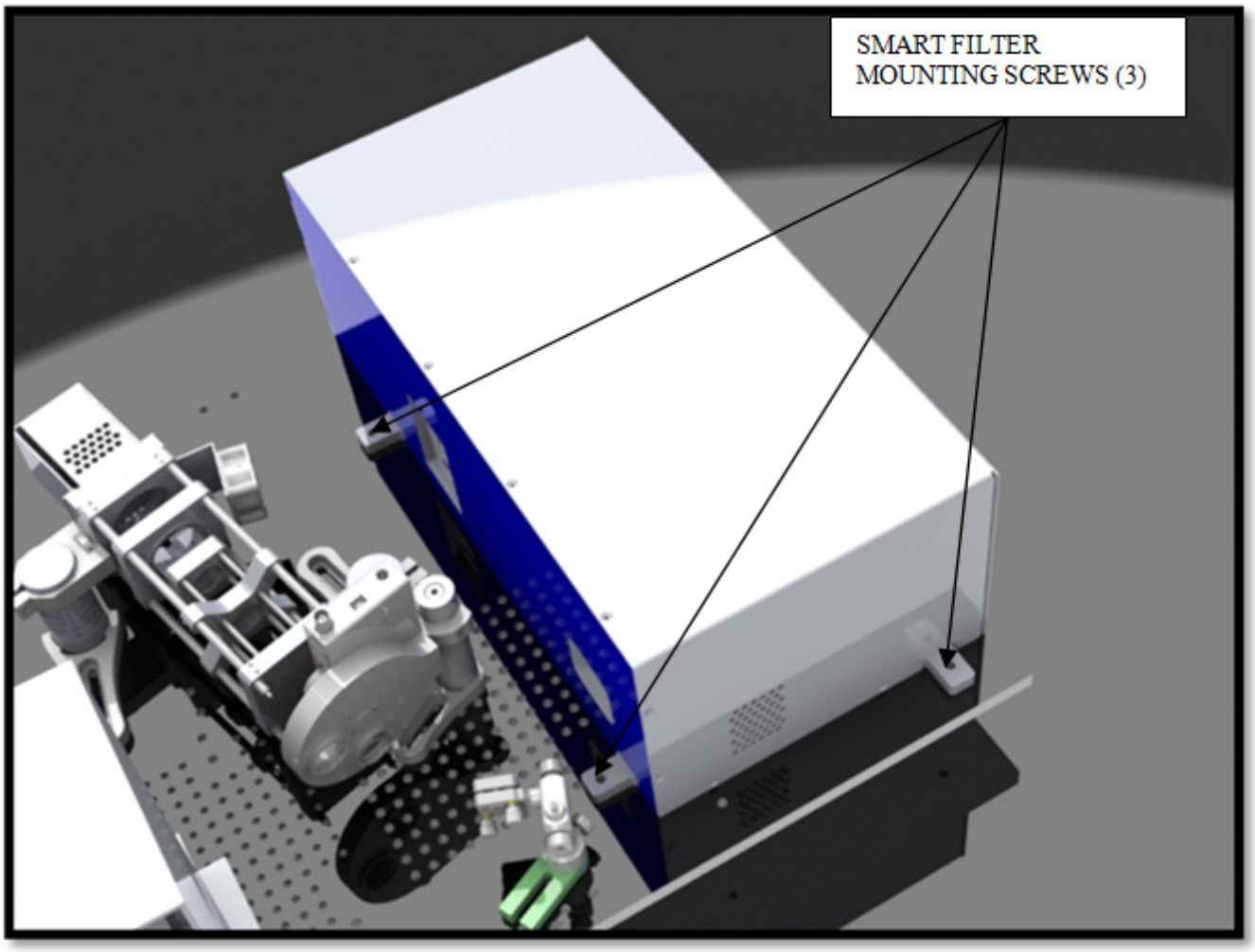


Figure 10.7.1: View of *Smart Filter*™ Sub-assembly

6. Remove the (2) two UNC #6-32 Phillips flat head screws on the back panel near the data port.

7. Detach the (4) four input connectors located on the left side of the *Smart Filter*™ near the terminal block. These connectors are keyed and unique to prevent incorrect re-insertion.

8. Using a 3/16" Allen wrench, remove the (3) three ¼ -20 socket head cap screws that attach

the *Smart Filter*™ sub-assembly to the unit base (*see Figure 1*).

9. Replace the *Smart Filter*™ unit. Do not attempt to repair the *Smart Filter*™ sub-assembly. Only factory authorized personnel are fully trained on the *Smart Filter*™ operation and maintenance.

10. Replace the three ¼-20 socket head cap mounting screws that attach the *Smart Filter*™ sub-assembly to the unit base.

11. Re-connect the (4) four input connectors located on the left side of the *Smart Filter*™ near the terminal block. These connectors are keyed and unique to prevent incorrect re-insertion.

12. Replace all system covers, being certain to use all supplied screws. Eliminating screws can cause EMI (electromagnetic interference) compatibility issues.

13. Plug the main power cable for the SF-100 Unit into the electrical outlet.

10.8 Replacing the System Cooling Fan

1. Turn off the SF-100 Unit using the switch at the rear of the unit. Disconnect the main power cable that powers the SF-100 Unit from the electrical outlet.

2. Remove the system cover.

3. Disconnect the power cable from the cooling fan.

4. Remove the (2) two ¼-20 socket head cap mounting screws that attach the cooling fan mount to the base.

5. Remove the fan and finger guard from the mount by removing the 4 sets of UNC #6-32 x 2” screws and washers (*see Figure 10.8.1*).

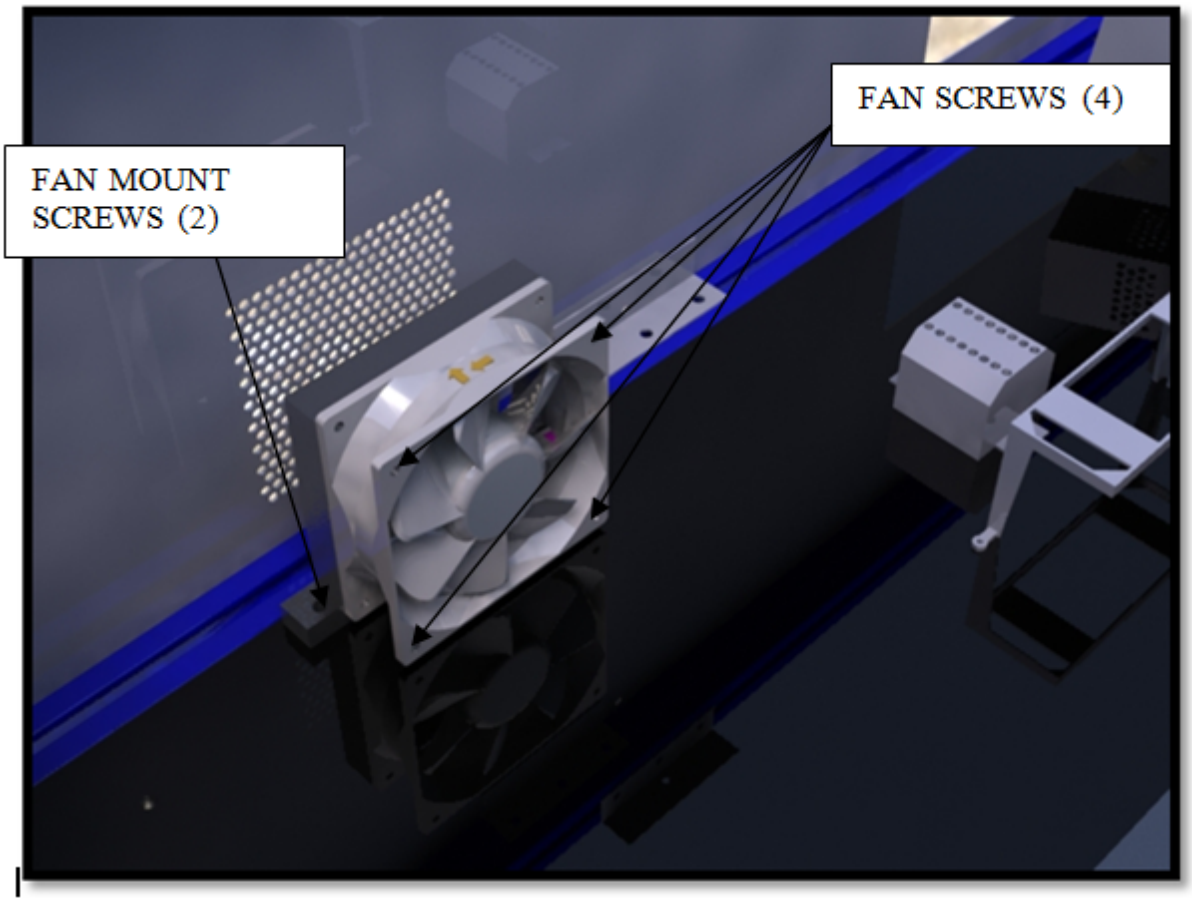


Figure 10.8.1: Top View of System Cooling Fan-Baffle Assembly

6. Secure the new fan and finger guard on to the mount with the air flow indication arrow directed outward from the unit utilizing the appropriate mounting screws.

7. Making certain the fan wires are not pinched under the fan or mount, secure the assembly to the base using the (2) two UNC ¼-20 socket head cap screws previously removed. When positioned correctly, there should be a gap (~1/2") between the fan mount and unit side panel. Incorrect mounting of the fan may result in lamp shutdown during system use.

8. Reconnect cooling fan power cable.

9. Replace the system cover and fasten all screws.

10. Connect the main power cable for the SF-100 into the electrical outlet turn on the unit, and

check air flow from the fan. Air should be blowing OUT of the system. If airflow is directed INTO the system, remove the cover and reorient the fan properly.

10.9 Optical Alignment Procedure

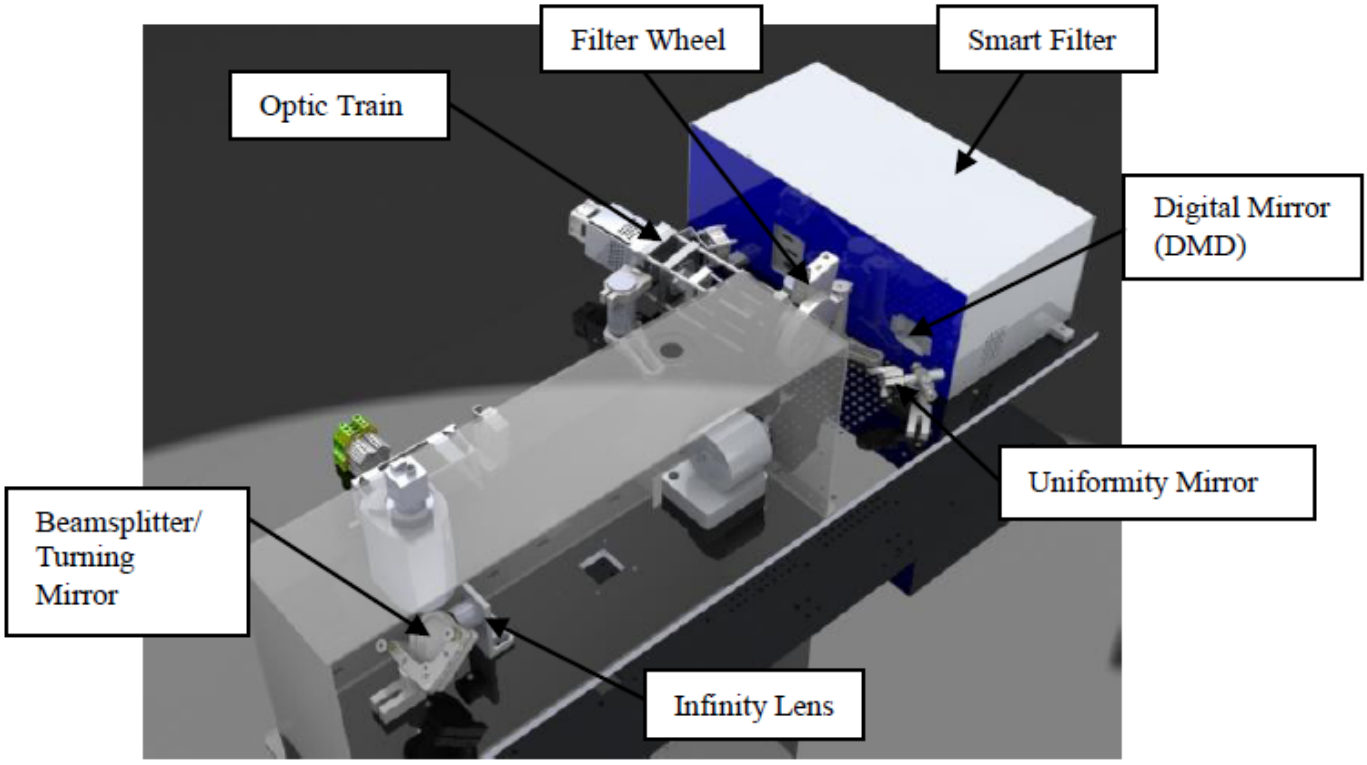


Figure 10.9.1: Complete optical path

Use caution when working inside (and around) the light source. Direct eye exposure with high optical energy can cause permanent eye damage. When working on the equipment near the light source or any area that may be exposed to this optical energy, it is recommended that you always wear approved safety goggles that provide protection from ultraviolet light.

Step 1: Alignment Preparation

Using a Phillips screwdriver remove the (10) 6-32 x ¼ PPH screws from the top cover of the SF-100. Lift the cover and place on the side of the SF-100. While the cover is lifted, looking at the brackets there is an interlock switch. When the switch is up and opened the user will not be able to connect to the SF-100. The interlock switch must be overridden. This can be done by placing a small piece of scotch tape across the switch; this will keep the switch in the down position (*see Figure 10.9.2*).

Figure 10.9.2: Interlock switch

Open up the front top door two the SF-100 so that the optic train and uniformity mirror can be adjusted from the top and the front of the system. Note there might be another interlock switch on the front of the tool. Once the panel is off and the door is open, tape down both interlock switches. Using the *Auto Stage*™ program in the Lamp Control tab re-connect the COM Port so that the computer is connected to the SF-100 and the lamp can be turned on.

Using the lamp control program turn the UV lamp on. The optic train must be properly aligned first. To do this the uniformity mirror should be installed or positioned so that the beam hitting the mirror it is reflecting off the *Smart Filter*™ illuminating the DMD (Digital Micro-mirror Device). It is best to set the mirror into position first before the optic train is aligned. This is an initial set up so that the light is hitting the DMD and more importantly sending the light through the middle of the reduction lens. This will help with the proper alignment of the Optic Train.

The Filter Wheel should be removed for ease of aligning the optics. Once the Optic Train is aligned and the Uniformity Mirror is set in the correct position then the Filter Wheel can be installed back in the light

path (shown later). With front panel opened disconnect the power and USB cable connected on the top of the filter wheel. Using an alen wrench, remove the screw holding the clamp on the Filter Wheel post and slide out Filter Wheel assembly (*see Figure 10.9.3*).

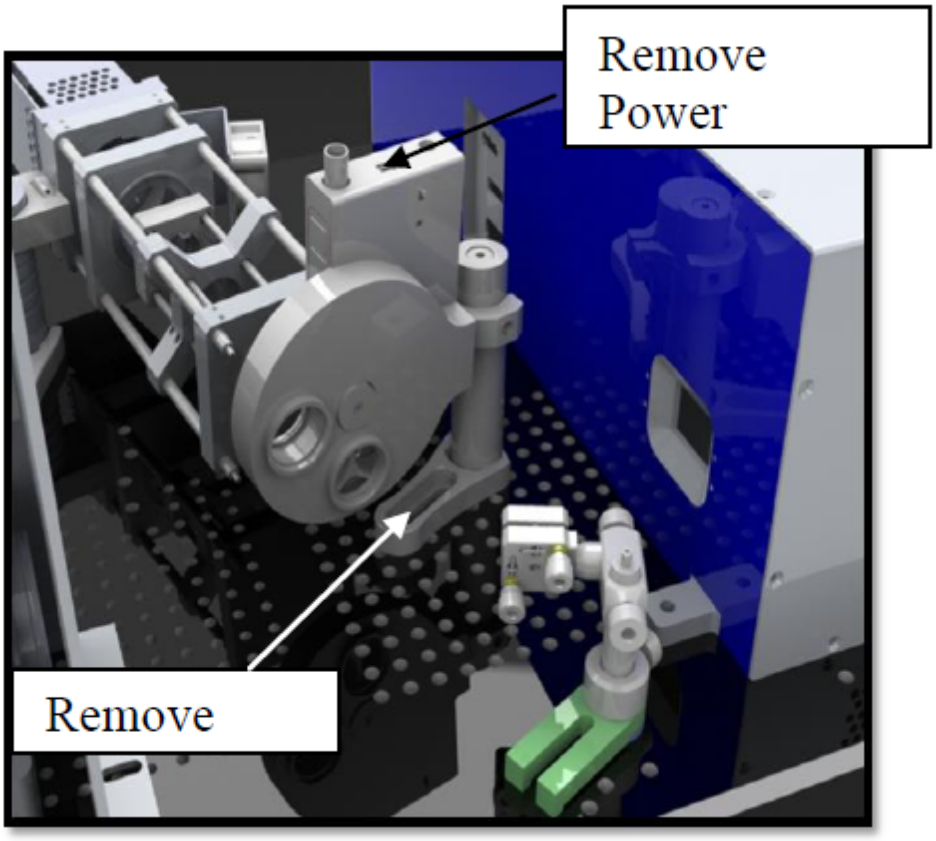


Figure 10.9.3: Removing the Filter Wheel

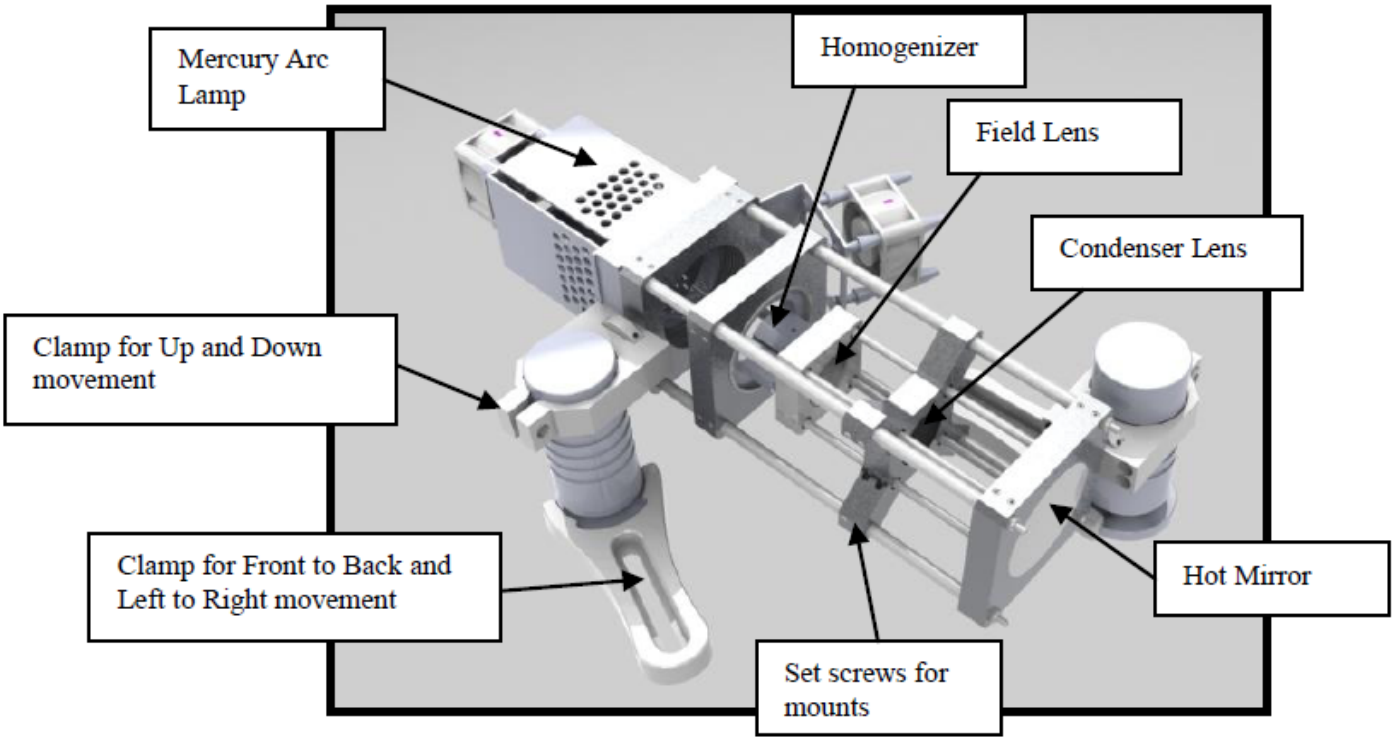


Figure 10.9.4: Optic Train components

Step 2: Optic Train Alignment

A white card (business card) will be needed, place the card up against the DMD so the image/light can be properly viewed (*see Figure 10.9.3*).

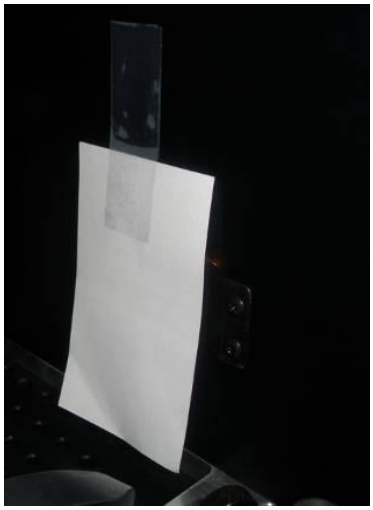


Figure 10.9.5: Business card over the Digital Mirror

All of the lenses in the optic train should be lock tight in the proper position. This position was set before the system shipped. If any adjustments need to be made (meaning there is not an in focus square of light hitting the DMD) then there is only one lens that needs to be adjusted, the condenser lens . The homogenizer is in a set position and the field lens is always up against the homogenizer (*See Figure 10.9.4 and Figure 10.9.8*).

CAUTION: When making the following adjustment, be aware that the assembly gets hot due to the UV lamp.

Loosen the 16 set screws on the condenser lens mounting bracket. This will allow the condenser lens to slide on the outer cage rails and inner cage rails, moving the light in and out of focus (*see Figure 10.9.6*). Make sure the field lens stays in the same position. Look at the white card while sliding the bracket back and forth to verify an in focus square over the Digital Mirror area (*see Figure 10.9.7*). Once the focus has been achieved tighten the 16 set screws down.

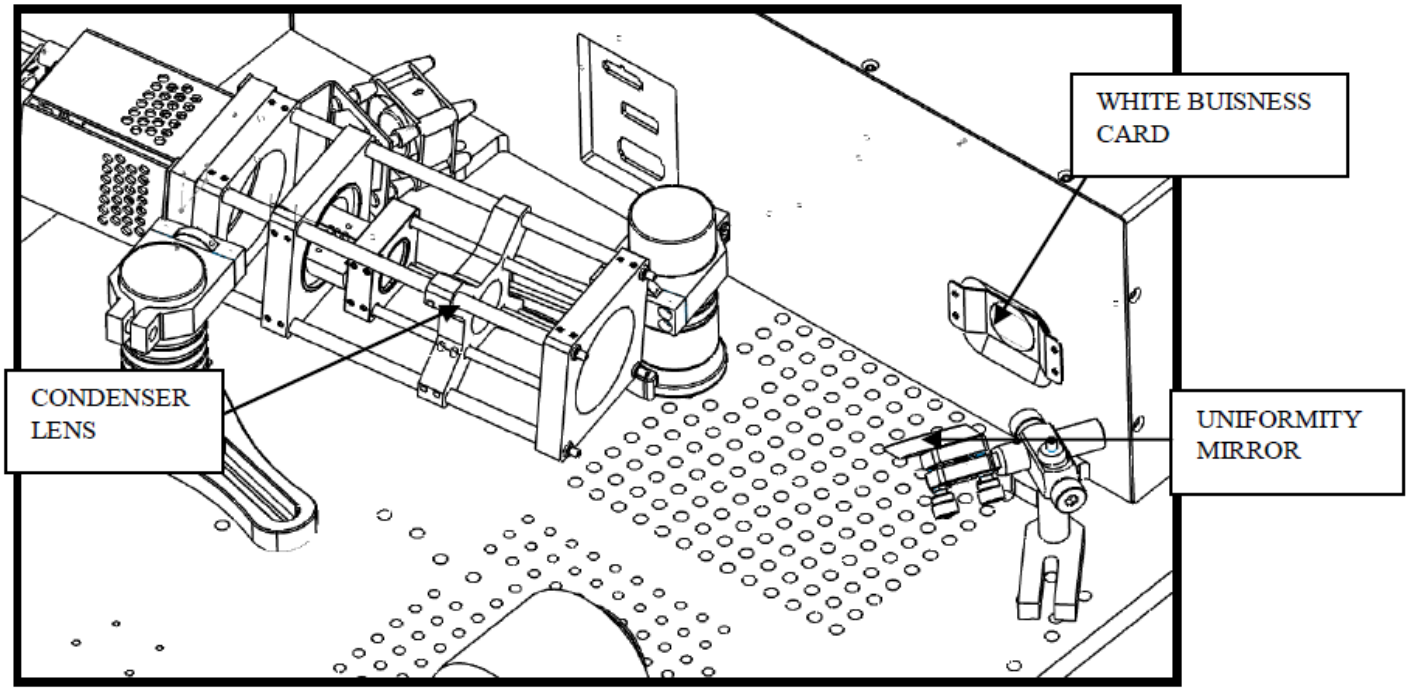


Figure 10.9.6: Side view of the Optics and Parts

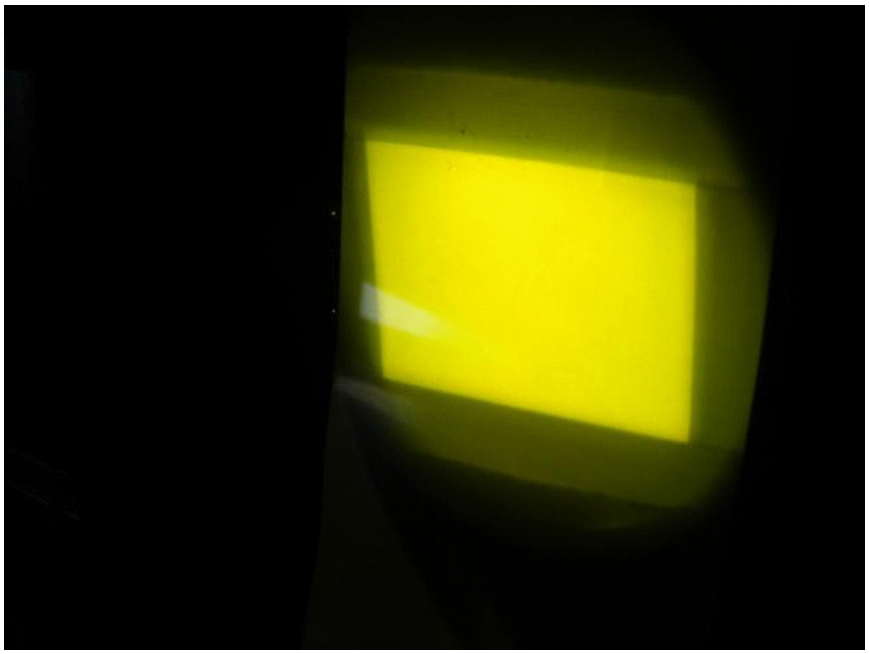


Figure 10.9.7: Image of the focused light on business card

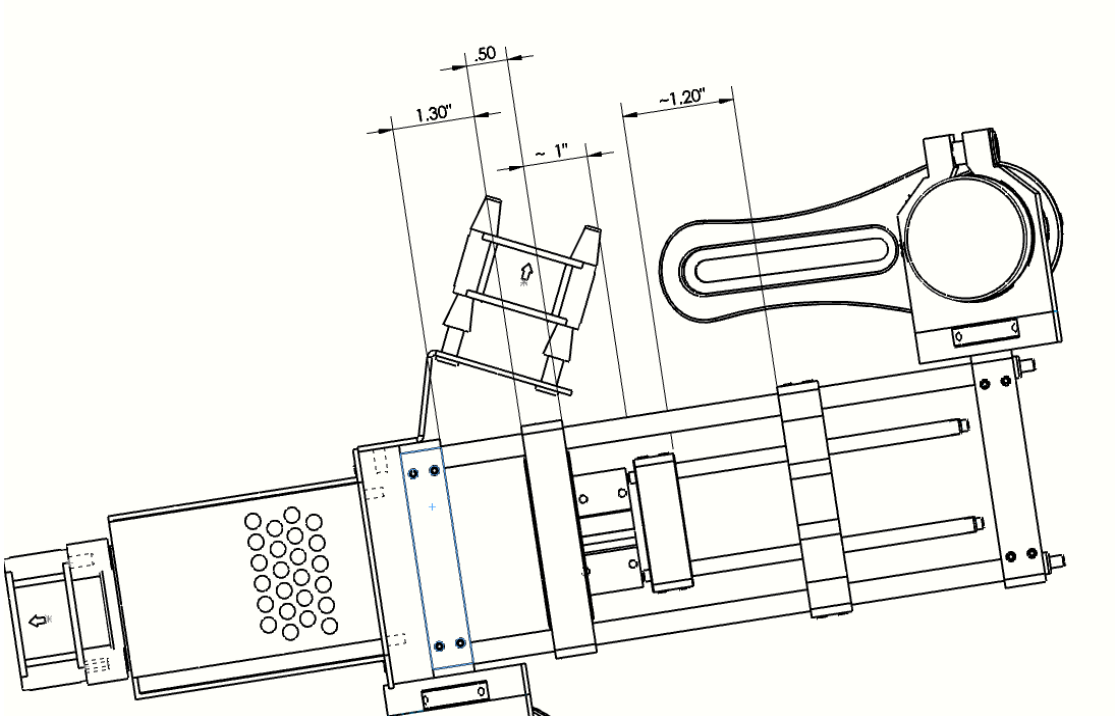


Figure 10.9.8: Established distances between the lenses on the Optic Train

After completion of the image adjustment the distance between the lamp mount and the field lens mount should be approximately 2.8”. The distance between the lamp mount and the condenser lens should be approximately 4.3” (*see Figure 10.9.8*).

Step 3: Uniformity Mirror Alignment

Shown below is an example of the image shining properly on the DMD should look reasonably centered (*see Figure 10.9.9*) **.**

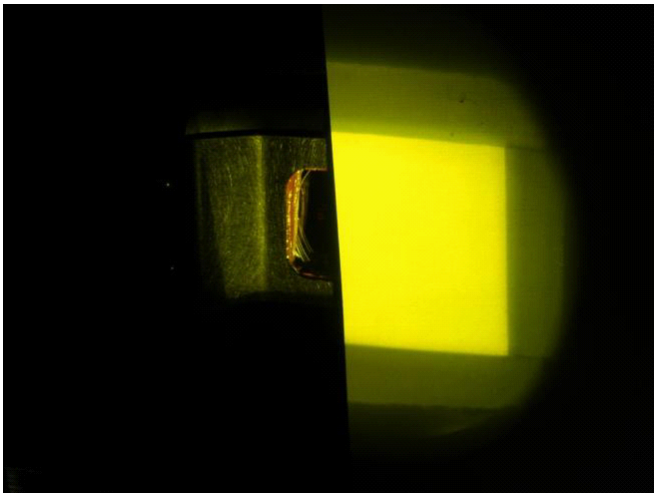


Figure 10.9.9: Image of the light properly hitting the DMD

The beam at the DMD should be uniform without any obvious irregularities; the whole DMD should be illuminated (verify that none of the corners are being clipped). If not, the Uniformity mirror will need to be adjusted. The Uniformity mirror has three course adjustable points making critical movements to the beam reflecting on the DMD. On the mirror post there are two turn knobs these will make fine adjustments to the beam.

The beam reflecting off of the DMD should hit the fixed lens directly center. Using the white card (business card) verify the bean entering into the lens is centered. The two knobs on the mirror will make fine adjustments, the knob on top will move the image up and down and the bottom knob will the image left and right (*see Figure 10.9.10*).

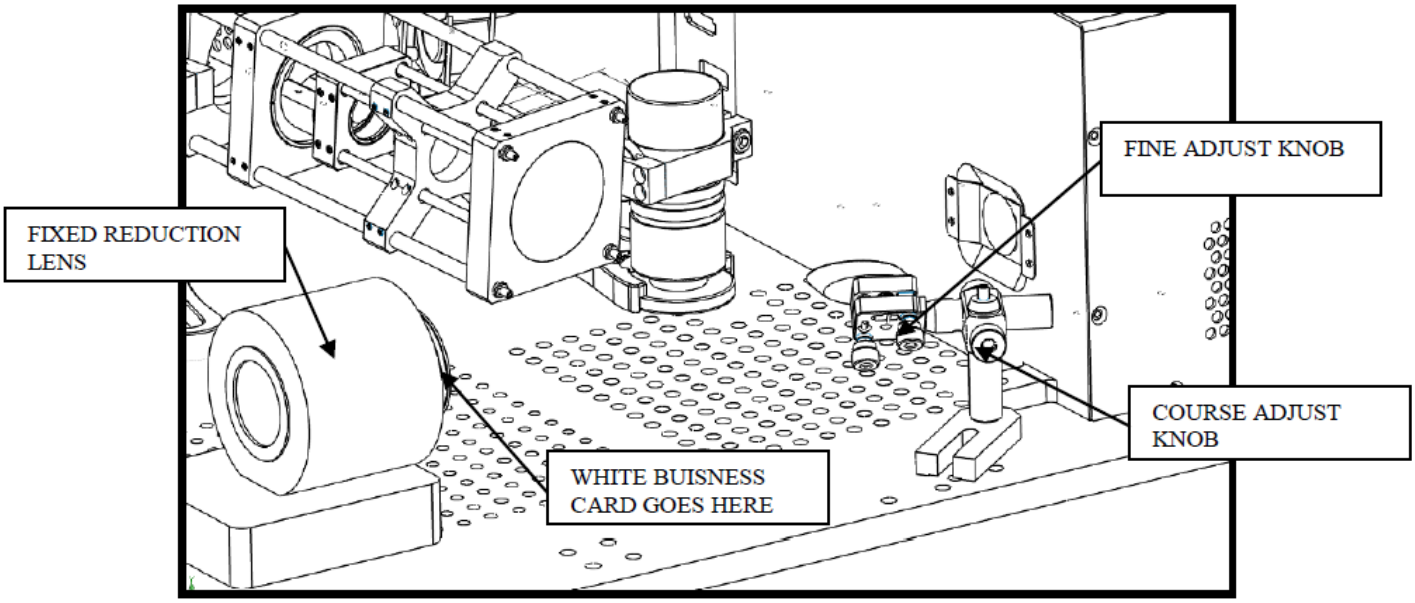


Figure 10.9.10: View showing adjustments for the turning mirror

The image appearing on the fixed lens will look somewhat like the image below. The center will have a brownish/tan color. You will need to make sure that the center of the beam is lined up with the center of the fixed lens (*see Figures 10.9.11 and 10.9.12*).

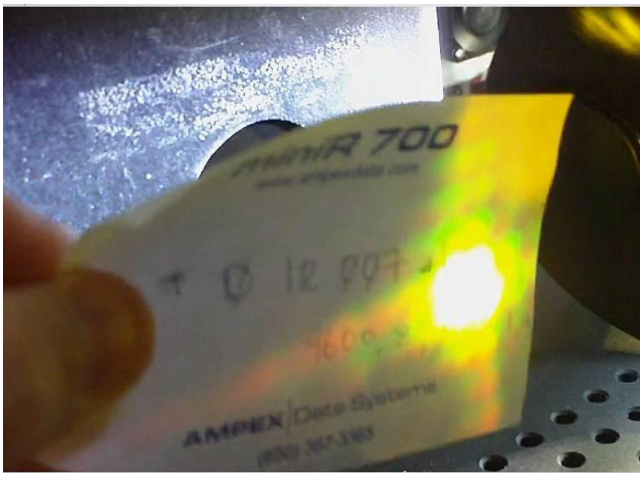


Figure 10.9.11: View of the light coming off the DMD

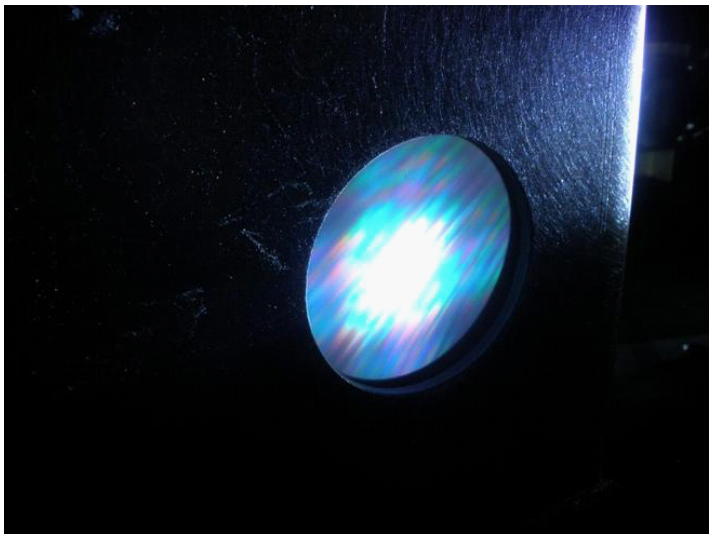


Figure 10.9.12: Light hitting a business card or center of the Reduction Lens

Step 4: Beamsplitter/Turning Mirror Alignment

The final adjustment is a focus adjustment. Using the software, load the bitmap image called “focusing image” . This image will come from the computer through the DMD (image of a plus mark). At this point the loaded image should be a being displayed on the focal plane (surface of the stage). Verify that the turning mirror is not clipping the beam. Check for dust, fingerprints, or dirt on the optical surfaces and clean if necessary. There are two thumb screws on the turning mirror. These screws are needed to make fine adjustments. The top thumb screw adjusts the image left and right and the bottom thumb screw adjusts the image up and down.

> Note: Before making adjustment to the focus mirror you will need these items: a reflective silicon wafer, a glass specimen slide and scotch tape.

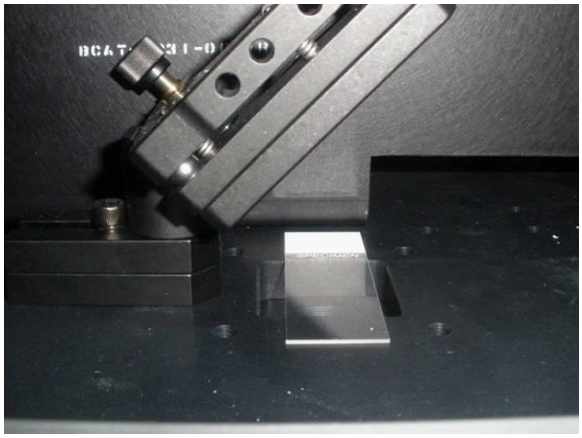


Figure 10.9.13: Glass slide for aligning the turning mirror

With the front panel flipped up place a specimen slide on top of the base plate right over the objective and underneath (*see Figure 10.9.13*).

The beam should shine through the glass specimen slide onto the substrate holder of the automated stage. Place a silicon wafer on the substrate holder, reflective side up. The reflection will reflect back up through the specimen slide and then to the camera. Looking closely at the camera adjust the shutter speed and gain until the plus mark image is visible. Using the fine adjust knobs on the focus mirror; line the two images up so they parallel each other. One image from the silicon wafer and the other from the glass slide (*see Figure 10.9.14*).

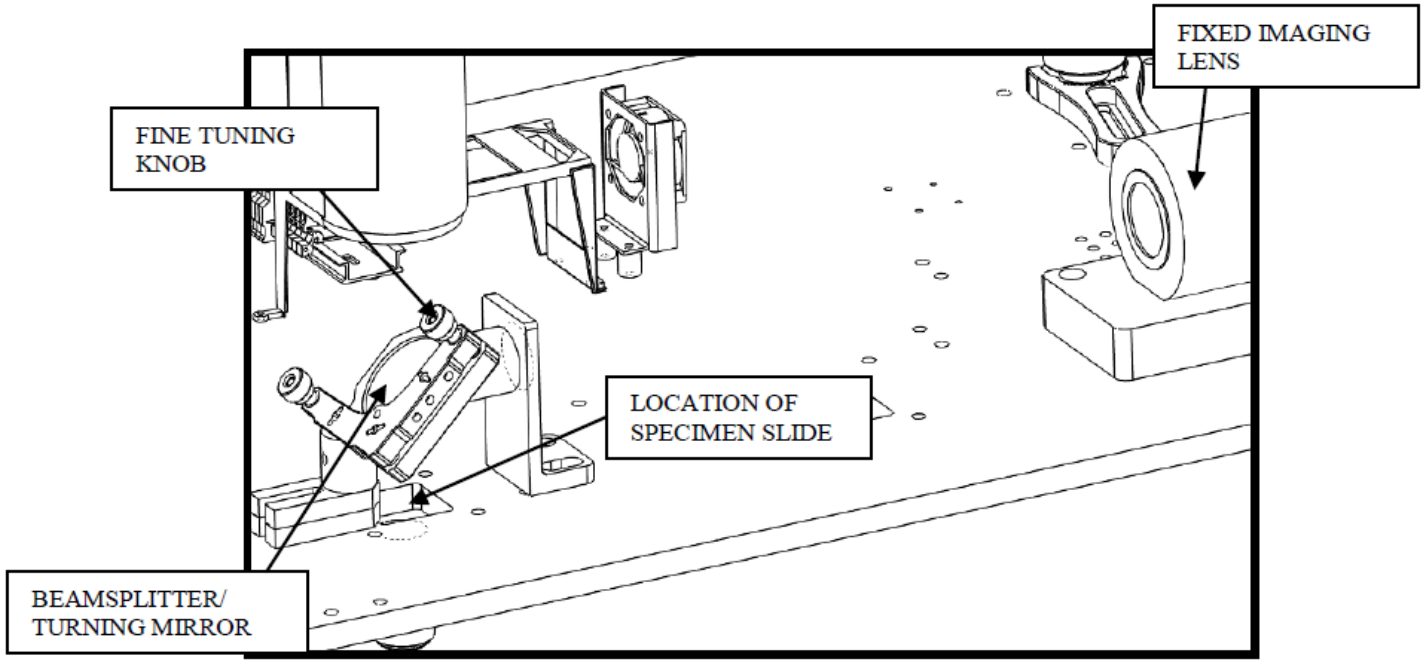


Figure 10.9.14: View for adjusting turning mirror

Once all the adjustments have been made the Filter Wheel can be put back in place in the light path.

Step 5: Inserting the Filter Wheel

Slide the post back into the mounting clamp and slightly tighten so that the filter wheel can still be moved. With the light on, move the filter wheel as close to the optic train as possible (*see Figure 10.9.15*).

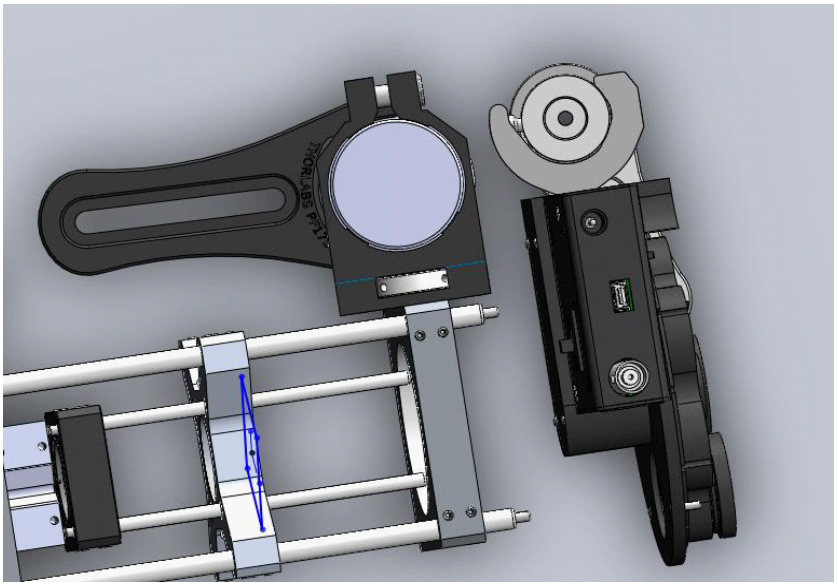


Figure 10.9.15: Inserting the Filter Wheel

Use the reflection of the light to help center the position of the Filter Wheel. You should see a square of light reflecting back on the optic train. Center this square of light to the center of the optic train (*see Figure 10.9.16*).

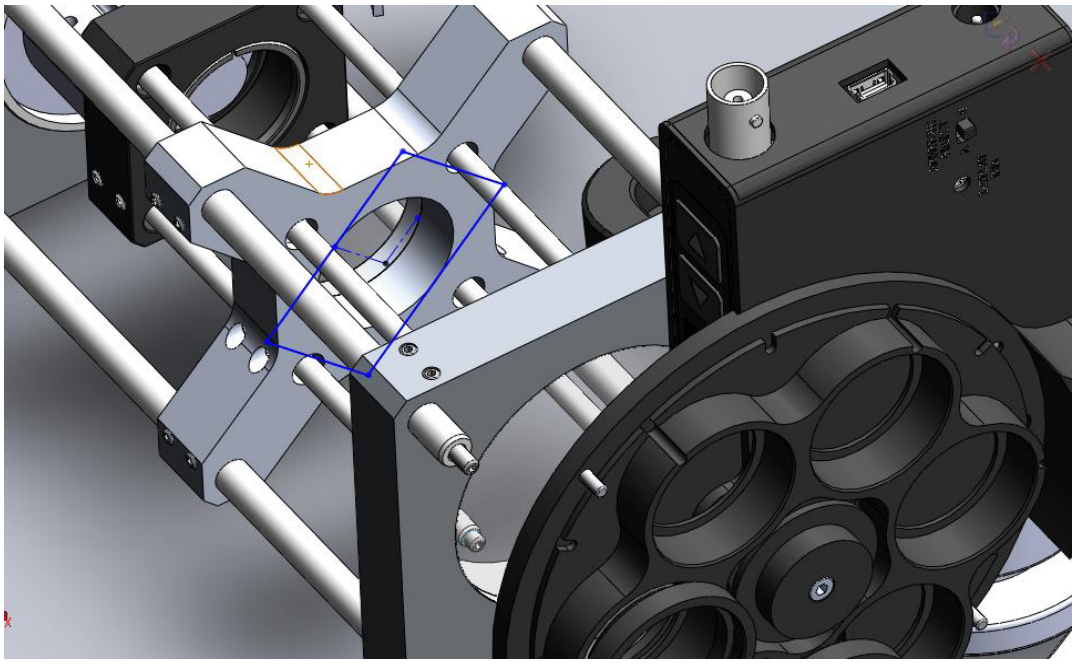


Figure 10.9.16: Centering the Filter Wheel

Once the Filter Wheel is in position tighten down the clamping post with the socket screw. The system may need to be tune to check and see if the stage is still aligned to the optics.

10.10 Updating Auto Stage™ Software

WARNING: This procedure is to only be used by an IMP engineer or under the direction of an IMP engineer.

1. Navigate to C:\Program Files\AutoStage by opening "My Computer" (Windows XP) or "Computer" (Windows 7). Locate Stage.exe and Stage.uir.

2. Back the existing files up by renaming them to Stage_old.exe and Stage_old.uir respectively.

3. Extract the compressed file, received from Intelligent Micro Patterning, to the C:\Program Files\AutoStage directory.

4. Depending on the software version you are updating from, it may be necessary for an Intelligent Micro Patterning Software Engineer to modify the profile settings for the various objective lenses. These can be found in the C:\Program Files\AutoStage folder, simply copy the text files and email them to IMP customer service.

10.11 Soft Reset of Automated Stage Controller

This procedure must only be performed under the direction of an Intelligent Micro Patterning Engineer. If there is any question as to whether or not this procedure should be performed, please contact IMP Customer Service. Circumstances that may require this procedure to be performed include: Temporary loss of power to controller (power outage), unexpected/inconsistent stage movement, misaligned center grid when performing the Tune XY procedure (after verifying that the "Home" command had been executed prior to the Tune). Choose the procedure that matches your controller, if you are unsure which controller your stage is equipped with please contact IMP customer service.

10.11.1 Delta Tau Controller

1. Double Click on the "Pewin32Pro2" icon on the desktop (If icon cannot be found on the desktop it will be located in either the "Delta Tau" folder on the desktop, or in the "Delta Tau" folder in the Start menu).

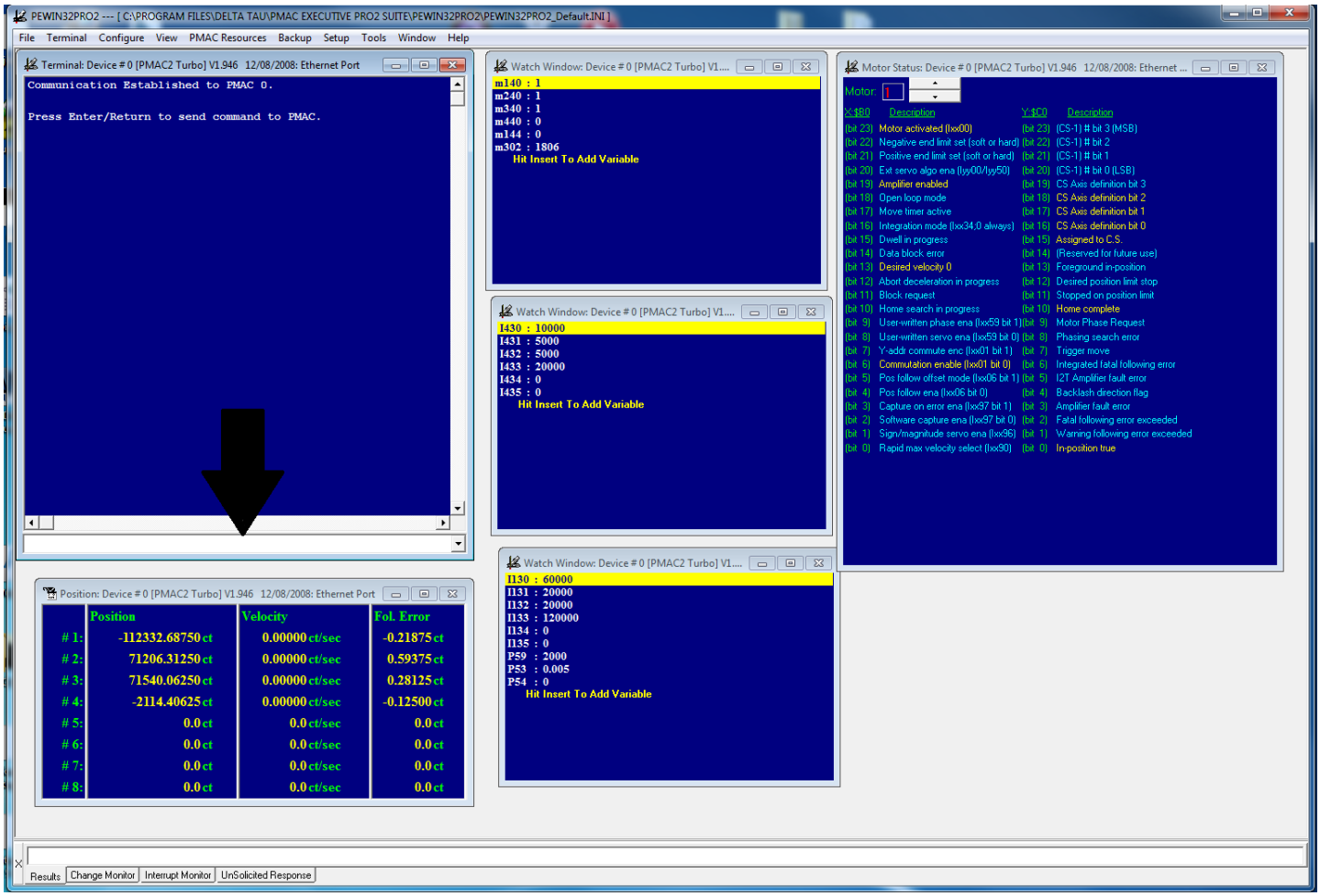


Figure 10.11.1.1: Screenshot showing the Pewin32Pro2 program and the location of the terminal user input (black arrow).

2. Once program finishes loading: Locate the terminal window (*see Figure 10.11.1.1*).

3. Click once at the bottom of the terminal window in the user input section (*see black arrow in Figure 10.11.1.1*).

4. Type "$$$", this command will reset the controller. Wait approximately 2 minutes before continuing.

5. In the user input section of the terminal window type "enableplc21" wait approximately 1 minute before continuing (This is a Home command for motor 1 of the stage).

6. In the user input section of the terminal window type "enableplc22" wait approximately 1 minute before continuing (This is a Home command for motor 2 of the stage).

7. In the user input section of the terminal window type "enableplc23" wait approximately 1 minute before continuing (This is a Home command for motor 3 of the stage).

8. STOP: Only perform step 8 if your stage is equipped with a Theta axis, otherwise skip this step (if you are unsure please contact IMP Customer Service). In the user input section of the terminal window type "enableplc24" wait approximately 1 minute before continuing (This is a Home command for motor 4 of the stage).

9. Your Delta Tau Stage Controller has been successfully reset at this point and you may close the "Pewin32Pro2" window. If your problem persists please contact IMP Customer Service.

INTELLIGENT
MICRO PATTERNING, LLC

Part XI

11 Artwork

The artwork for the tool is vital, because it controls the Digital Micro-Mirror Display (DMD). The black sections of the artwork turn off the mirrors so that they do not reflect light on the substrate, the white sections turn the mirrors on so that they are reflecting light onto the substrate. The gray sections cause the mirrors to turn oscillate between the "on" state and the "off" state at a specific frequency in order to create the appropriate grey value.

Using a Digital Signal Processor (DSP) controller, the mirrors on the DMD are controlled with binary Pulse Width Modulation (PWM) allowing up to 16 bits of gray scale values per pixel. As bits per pixel increase the refresh rate will decrease. To obtain at least a 120 Hz (8.3 ms) refresh rate, 10 bits per pixel is chosen, resulting in 2^{10} (1024) gray values and a maximum refresh rate of 142 Hz.

Bits per pixel	Gray values generated	Refresh rate (frames/ sec)
1	Binary	6918
2	4	3334
3	8	2215
4	16	1451
5	32	936
6	64	557
7	128	308
8	256	162
9	512	n/a
10	1024	142
11	2048	n/a
12	4096	38
13	8192	n/a
14	16384	9
15	32768	n/a
16	65536	2

Table 11.1: Showing Grey Values & Refresh Rate with Differing Bits per pixel

Although a DMD with the configuration seen in table 1 is capable of outputting 2^{10} (1024) shades of gray, the SF-100 is limited to the maximum shades of gray existing in a 24-bit bitmap image, currently the highest quality bitmap used by Microsoft Windows. In a 24-bit bitmap image there are 3 eight bit components making up the 24-bit image; Red, Green, and Blue. Therefore, each component has 2^8 (256) possible states translating to: 256 x 3 = 768 total shades of gray.

11.1 Design Guidelines

Design Guidelines	2x Reduction Lens	4x Reduction Lens	10x Reduction Lens	20x Reduction Lens
Maximum Design Size	6 x 6 inches	6 x 6 inches	4 x 4 inches	4 x 4 inches
Minimum Feature Size	10um*	5 um*	2 um**	1 um**
Pixel Size	2.5um	1.25 um	0.50 um	0.25 um

Table 11.1.1: Design guidelines for various objectives

***** Qualified with Shipley 1827 positive photoresist
** Qualified with Shipley 1805 positive photoresist

Maximum Design Size
Based on DWG TrueView 2011 for file conversions, the maximum design size is stage dependent. This translates to a maximum design sizes listed above.

Stitching Accuracy
Due to use of Raster images, a typical ±0.5 pixel stitching error is introduced into the movement of the stage on a system that is correctly tuned. Although, it is possible to minimize this error by modifying the display properties inherit within the stage program. Flatness of the substrate will also have an effect on stitching accuracy.

CAD Designs

Raster images are used for exposition, rather than vector based designs so all CAD designs need to be filled in (hatched) properly to represent both dark and light fields for proper conversion. Units (imperial or metric) need to be assigned as well. Since many CAD programs do not assign units of measure the proper units must be assigned rather than leaving it as unit less.

Overlay Accuracy for Multiple Level Designs

NI Vision software offers 1/10 pixel edge detection accuracy

	Load Single Image (under 18000 sq. pixels)	Load Image Directory (over 18000 sq. pixels)	DPI
2x objective	45mm x 45mm	Stage Dependent	10160
4x objective	22.5mm x 22.5mm	Stage Dependent	20320
10x objective	9mm x 9mm	Stage Dependent	50800
20x objective	4.5mm x 4.5mm	Stage Dependent	101600

Table 11.1.2: Maximum File Sizes for Loading a Single Bitmap

11.2 Converting DXF/DWG to Bitmap

Note: The conversion was done using a Windows 7 x64 based PC with 8GBs of Ram. The first section of this procedure deals with adding a Bitmap Plotter to DWG TrueView 2011. This only has to be done one time. Simply skip the first section, if this procedure has been previously completed.

Adding a Bitmap Plotter to TrueView

1. A Windows Bitmap Plotter needs to be created if one does not all ready exist. This is done by clicking on  and selecting "Print", "Manage Plotters". Within the plotter manager popup locate the “MS-Windows BMP” plotter.

2. If it does not exist double click on the “Add-A-Plotter Wizard” icon to add a plotter.

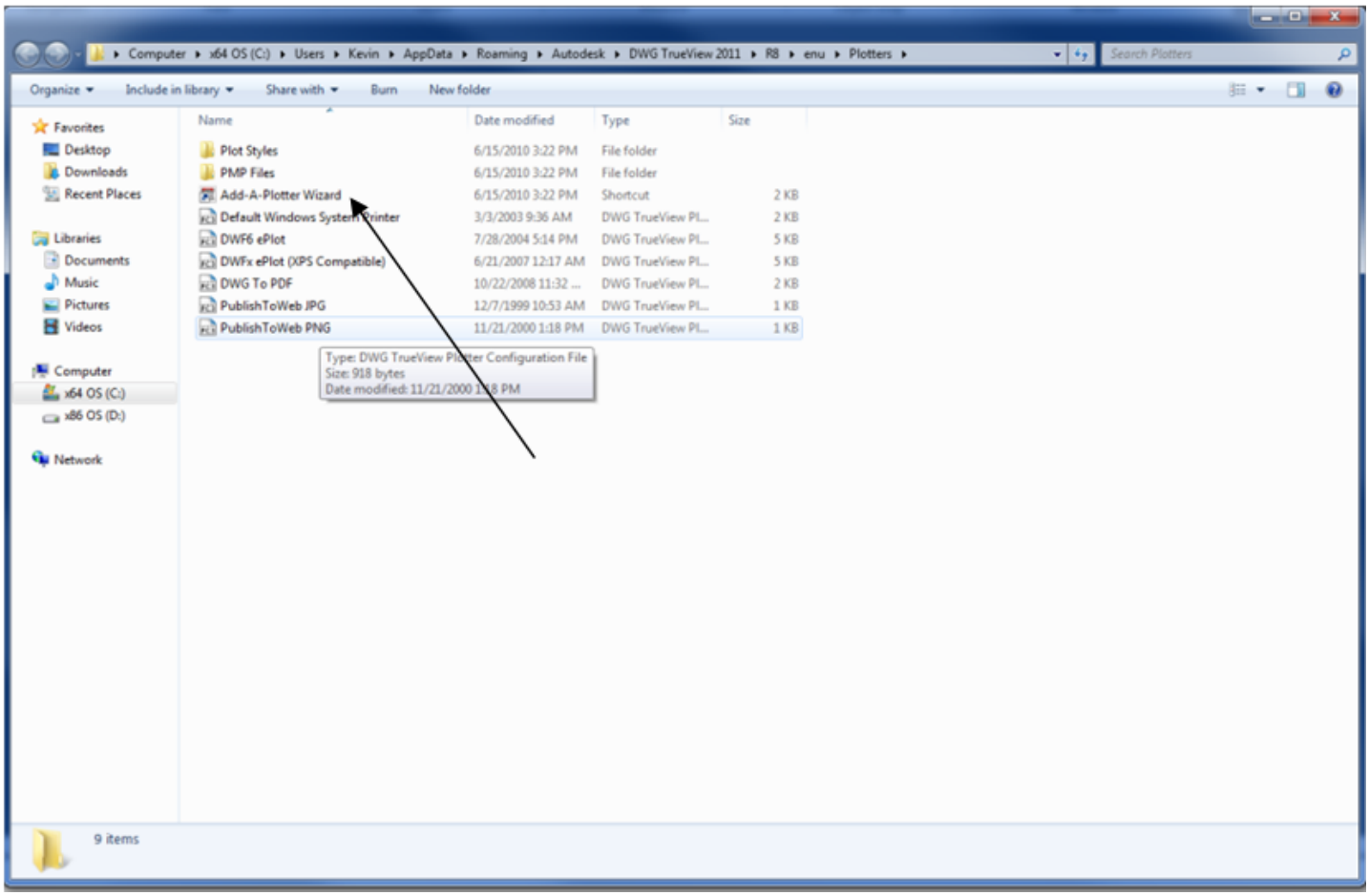


Figure 11.2.1: Location of Add-A-Plotter Wizard

3. When the add plotter popup is displayed click “next” to continue. The first parameter to set is the plotter location. This should be set to “My Computer.” Click “Next” to continue.

4. The second parameter to set is the plotter model. Select “Raster File Formats” from the Manufacturers list, and then “MS-Windows BMP” from the Models list.

5. The remaining parameters do not need to be changed, so continue to click “Next” until the wizard closes and the “MS-Windows BMP” icon is visible in the Plotters popup.

6. Now that the plotter has been created, a couple of parameters need to be modified for the plotter. The plotter configuration editor can be opened by double clicking on the desired plotter and selecting the “Device and Document Settings Tab.”

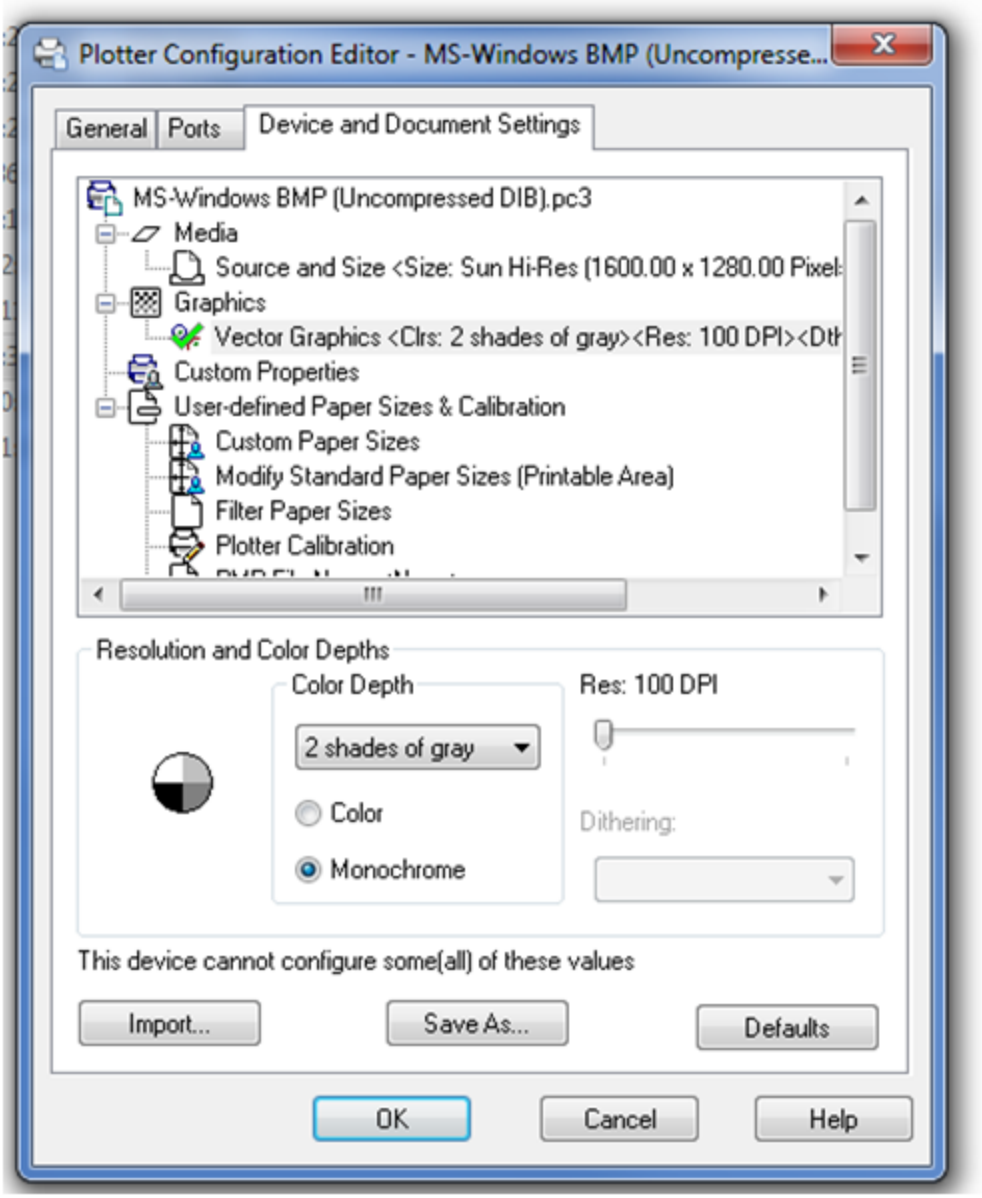


Figure 11.2.2: Bitmap Plotter Configuration Window

7. The first parameter that needs to be modified is the Graphics. It needs to be changed to a monochrome color depth with 2 shades of gray. This will ensure that the bitmap will be plotted in black and white, with a relatively small file size.

   Note: Since a monochrome 2-bit color depth is chosen, the design to be converted must be drawn in black and white.

8. The second parameter that needs to be modified is the paper size. This is controlled in the

"Custom Paper Size" item.

9. The paper size will need to be large enough to house the complete drawing. It is designated in pixels, so a conversion will be necessary. To determine the paper size, the following equations can be used.

page width = drawing width / pixel size
page height = drawing height / pixel size

Example: The artwork in Figure 3 measures 17.39mm x 7.86mm. If a pixel size of 0.250 micrometers is desired:
The width of the paper would need to be at least 17.39mm / 0.000250mm/pixel = 69560 pixels.
The height of the paper would need to be at least 7.86mm / 0.000250mm/pixel = 31440 pixels.
For ease of conversion, which will be discussed in the next section it is best to increase the height of the paper to a number divisible by 1000, such as 32000 pixels. It also might prove beneficial to increase the width of the page a nominal amount to ensure the image is not clipped.

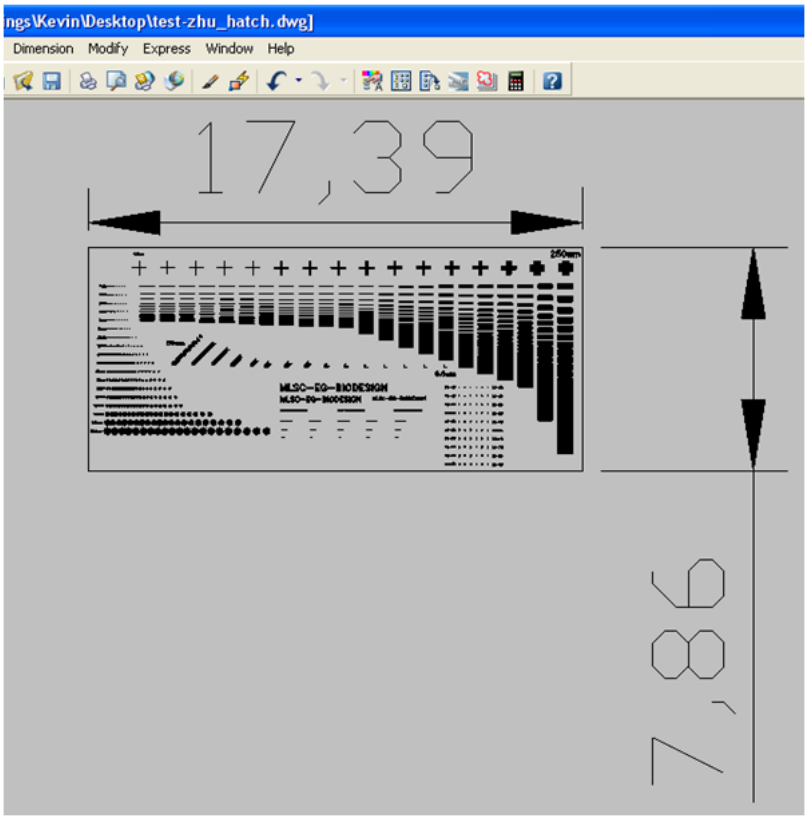


Figure 11.2.3: Example Artwork

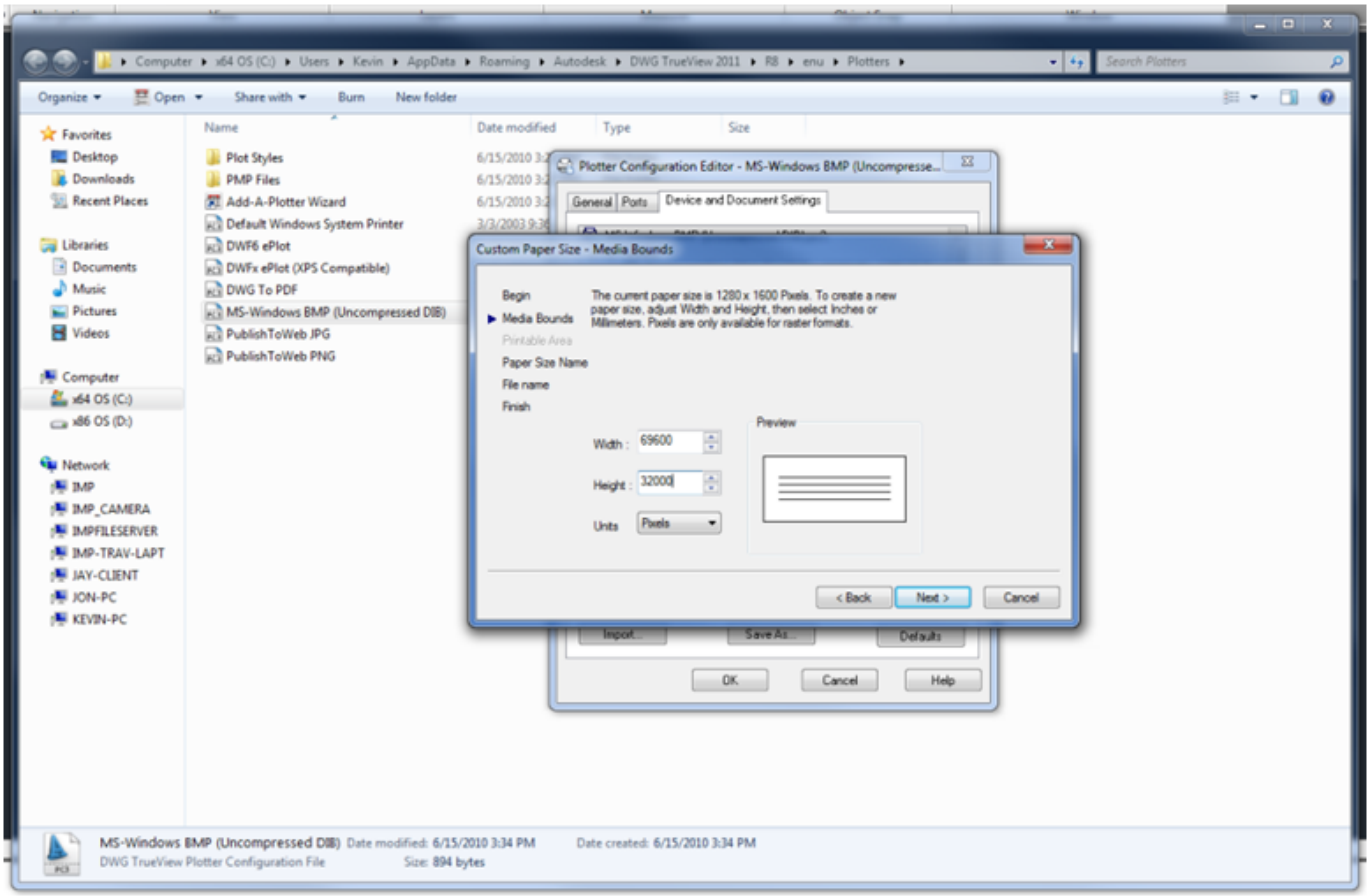


Figure 11.2.4: Setting Custom Paper Size

Plotting the Artwork in DWG TrueView

1. The final step is the actual process of plotting the artwork. To do this, click on  and select "Print." This will display the plot popup.

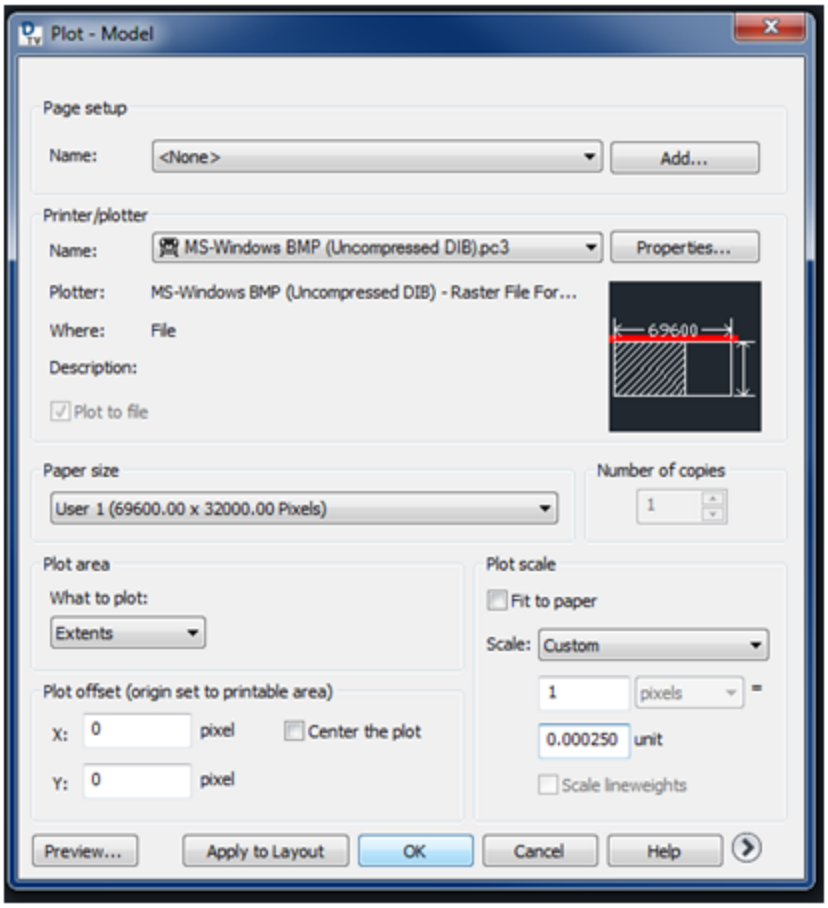


Figure 11.2.5: Plot Window

2. Within the plot popup the plotter needs to be selected, select “MS-Windows BMP” from the pull down list.

3. Next the paper size will need to be selected, select the paper size created in the previous step from the pull down list.

4. Lastly the plot scale will need to be set. To do this, uncheck “Fit to paper” and change the units value to the desired pixel size: 0.000250 mm, 0.001250mm, ECT.

5. It is now possible to preview the plot by clicking “Preview” or create the plot by clicking “OK.” When “OK” is clicked, a file save popup will be displayed. Save the file and continue.

   Note: The plotting process will take some time to complete. Once completed, the bitmap file can be previewed.

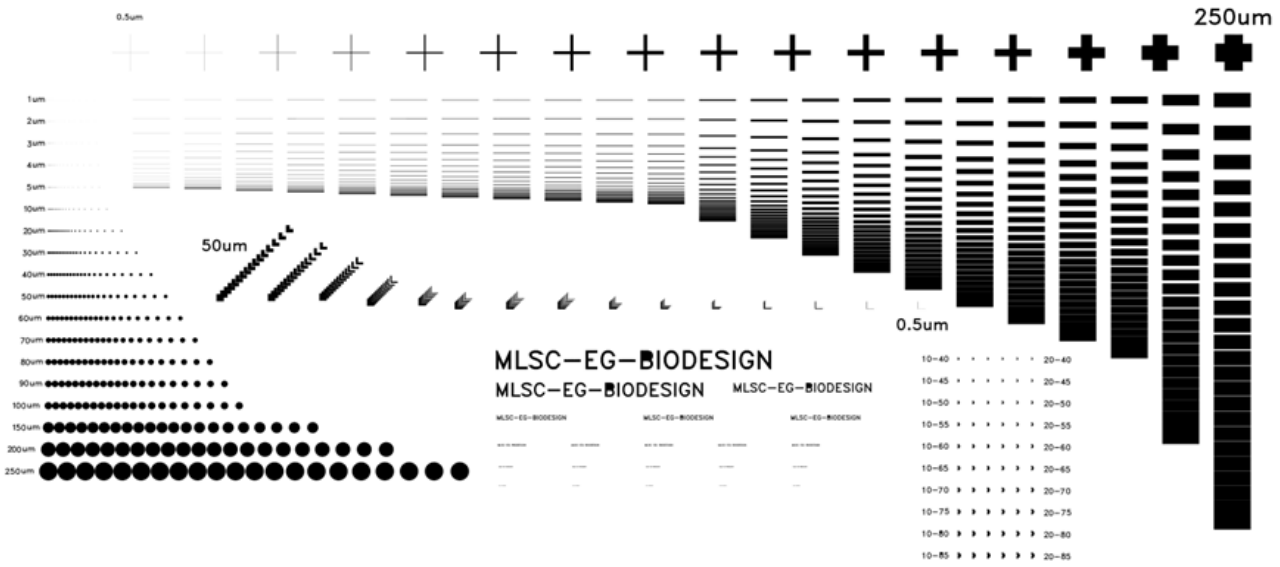


Figure 11.2.6: Final Bitmap of Example Artwork

11.3 BMP Parser

Note: Before performing this procedure the Bitmap plotter must be setup in DWG TrueView, this need only be completed once (Refer to "Converting DXF/DWG to Bitmap")

Using BMP Parser to Create BMP Files From DXF/DWG Files

BMP Parser uses the command line in DWG TrueView to create an array of bitmap files that can be loaded directly into the *Auto Stage*™ program. In order for this process to be completed successfully, the user is required to input the following information (*see Figure 11.3.1*).

Note: This program must be run with administrative privileges.

The “Canvas Width” and “Canvas Height” controls must be setup to match the width and height of the input cad file.

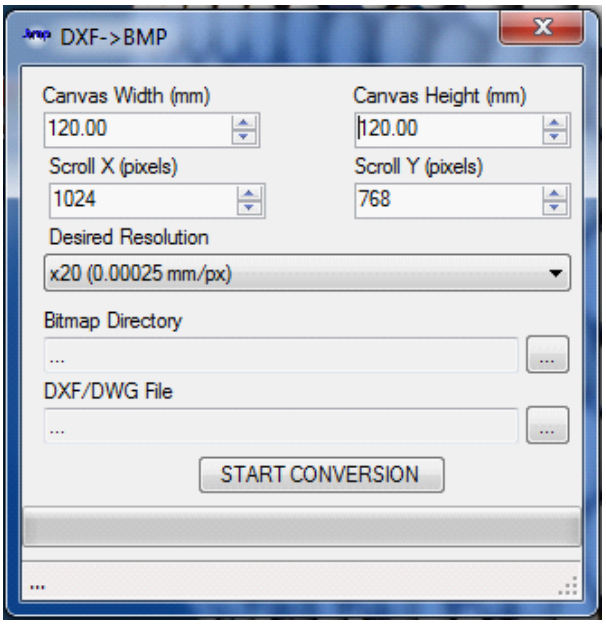


Figure 11.3.1: BMP Parser screen

Next “Scroll X” and “Scroll Y” need to be set. By default their values are 1024 and 768 respectively. The difference Scroll X and 1024 as well as with Scroll Y and 768 represent the pixel overlap of the adjacent images in the array of bitmaps created. Values of 1024 and 768 represent a zero pixel overlap, where as values of 1004 and 748 represent an overlap of twenty pixels. For “Scroll X” a value of 1004 is recommended and for “Scroll Y” a value of 748 is recommended (*see Figure 11.3.2*).

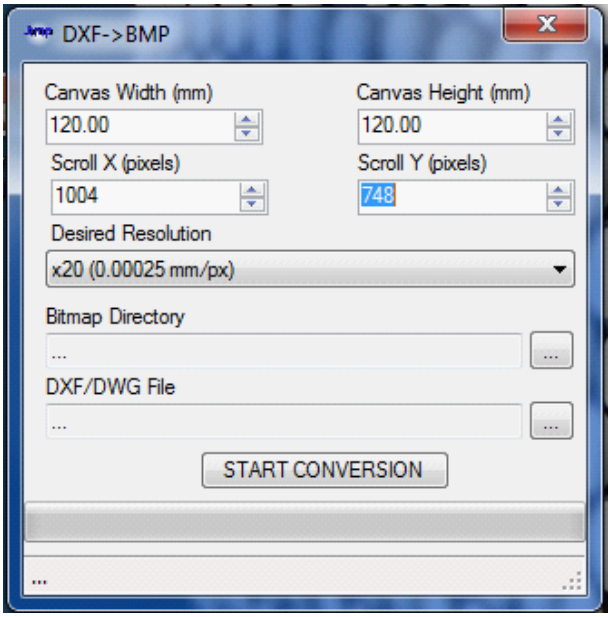


Figure 11.3.2: Recommended Values for "Scroll X" and "Scroll Y"

After setting the scroll values the “Desired Resolution” can be selected (*see Figure 11.3.3*). There are four options to choose from: x20, x10, x4, and x2. Choose the magnification that matches the reduction configuration of the system.

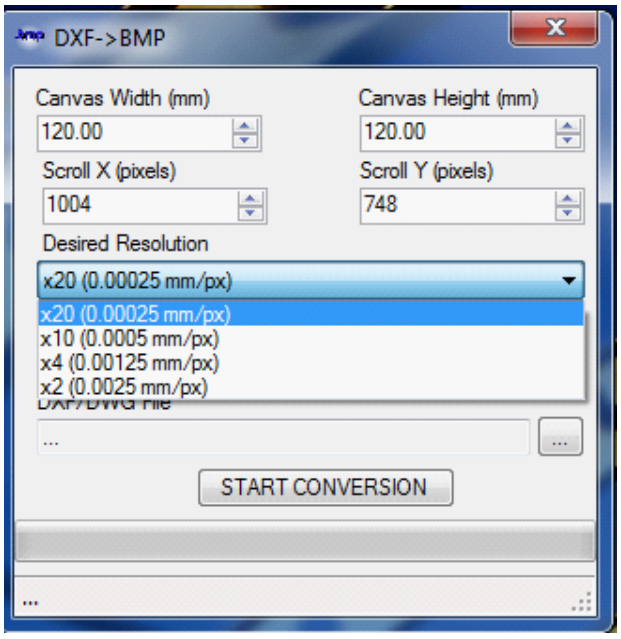


Figure 11.3.3: "Desired Resolution" options

Next select the Bitmap Directory; the folder in which to save all new bmp files. The directory selected must be empty. If any files exist a popup will be displayed prompting whether to delete all files or select a new directory (*see Figure 11.3.4*).

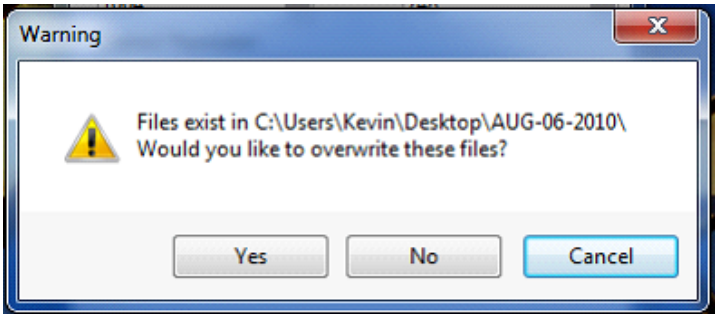


Figure 11.3.4: Warning Popup

The final step before starting the conversion process is to select the DWG/DXF file to convert. Once the desired file is selected, click on "START CONVERSION" to begin the conversion process. The process may take some time to complete. Three background processes run during the conversion: Script Writing, File loading, and Bitmap Writing. The progress of each step can be monitored as seen in *Figures 11.3.5, 11.3.6*, and 11.3.7.

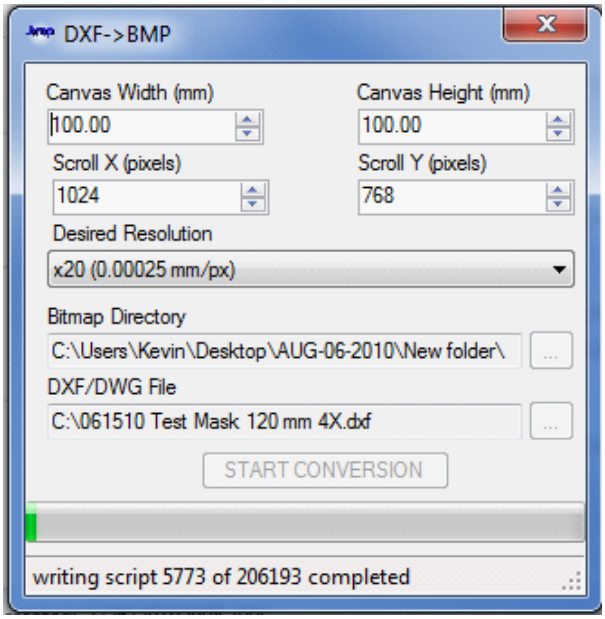


Figure 11.3.5: Writing script

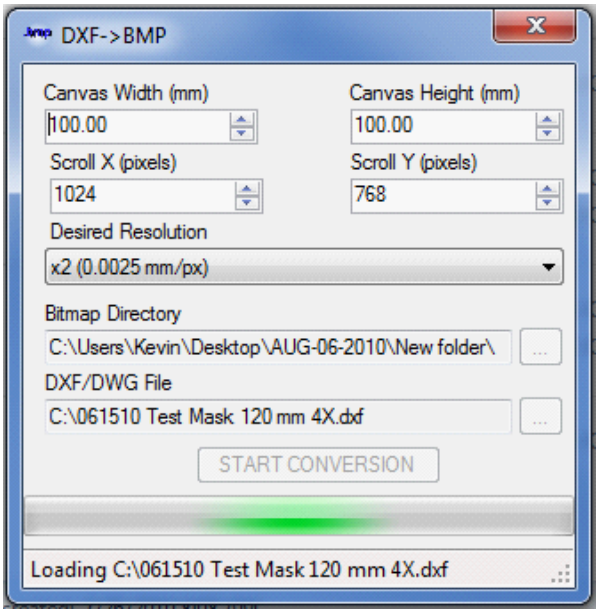


Figure 11.3.6: Loading DXF file

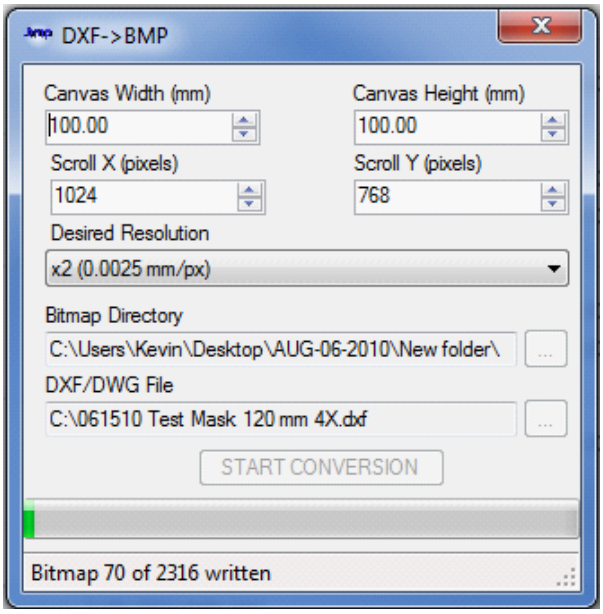


Figure 11.3.7: Writing Bitmaps

During the conversion process, the BMP Parser program cannot be modified or closed. Trying to close the program will result in the popup seen in *Figure 11.3.8*.

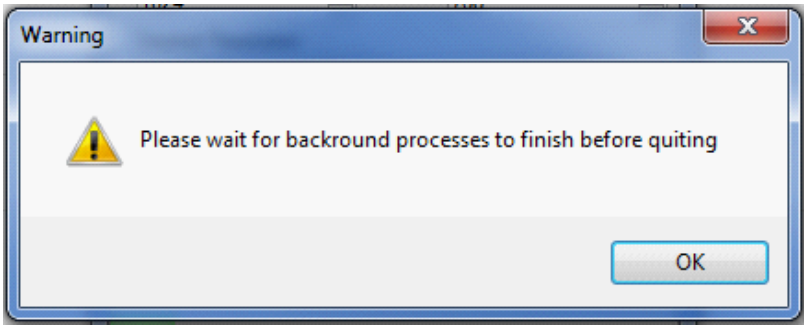


Figure 11.3.8: Warning popup

Upon completion the bitmap directory should be inspected for completeness and accuracy (*see Figure 11.3.9*).

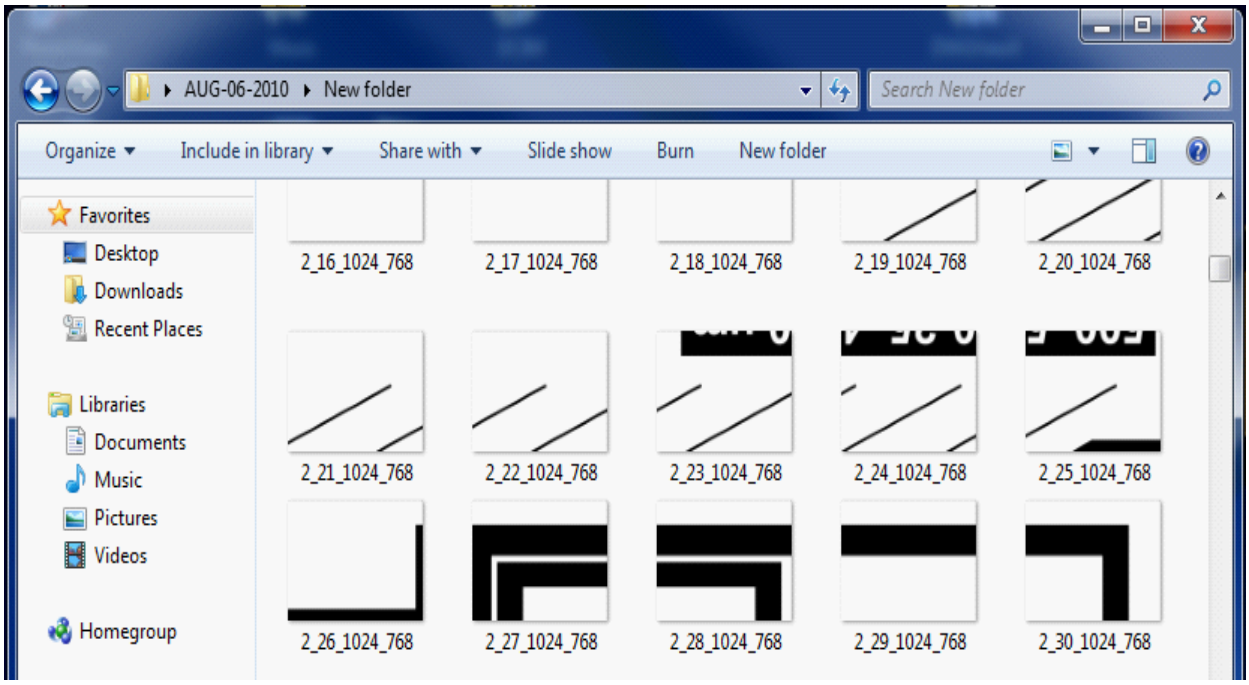


Figure 11.3.9: Folder showing bitmaps

11.4 GS Draw

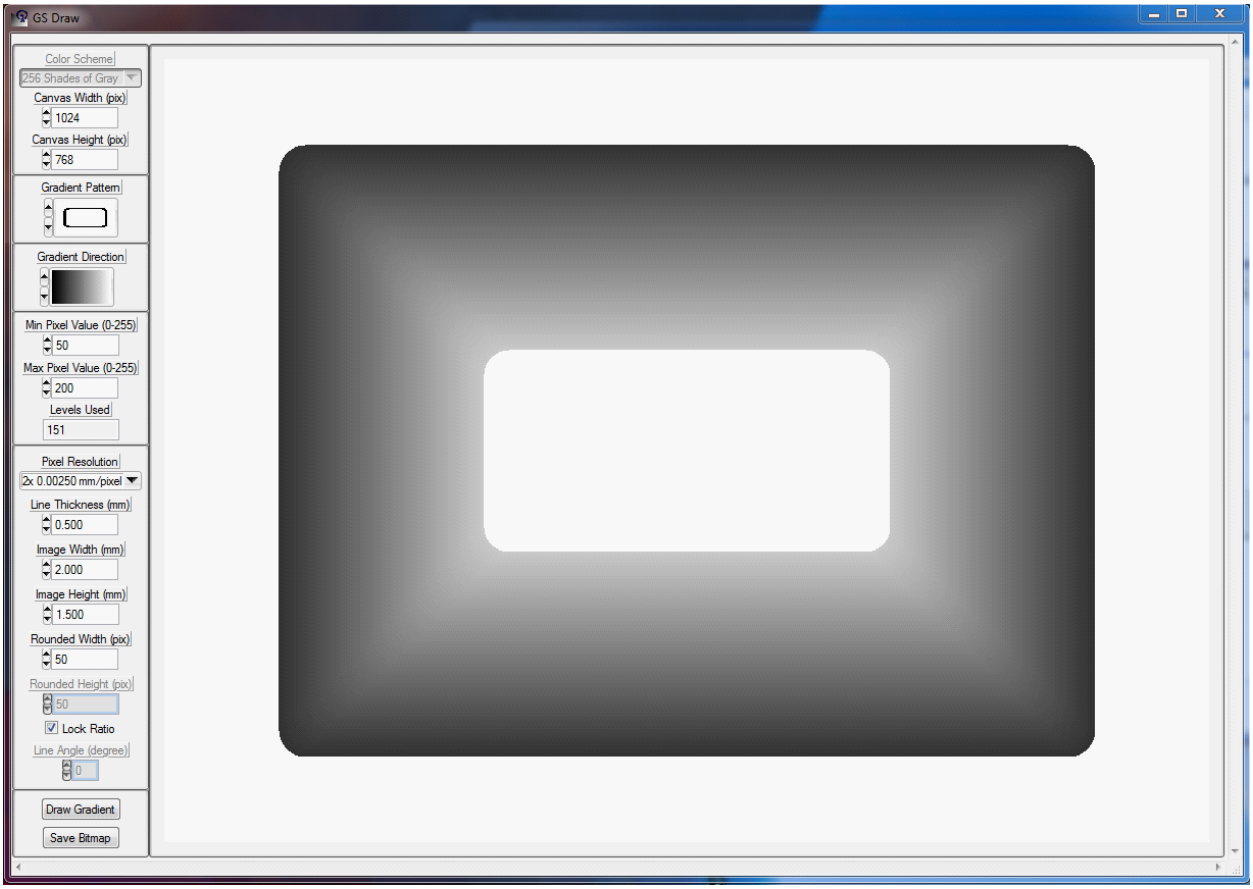
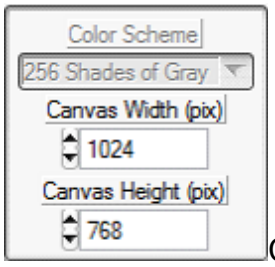


Figure 11.4.1: GS Draw Main Window with Example Artwork

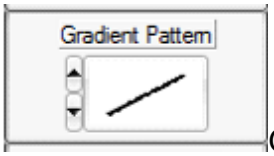
Introduction

GS Draw is a program written by Intelligent Micro Patterning to aid in the creation of multiple different shapes filled with grey scale gradients. Shapes available include rotated lines, rectangles, rounded rectangles, and ovals. By creating a shape and specifying minimum and maximum gradient pixel color weights as well as the gradient thickness, the program will fill the chosen shape with the desired gradient.

Understanding the tool bar

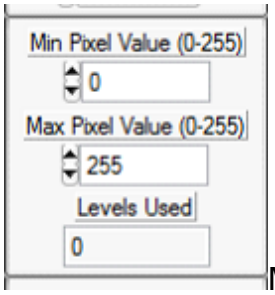


Color Scheme: Depicts the color table used to create the gradient.
Canvas Width: Sets the width in pixels of the Canvas used for all drawings.
Canvas Height: Sets the height in pixels of the Canvas used for all drawings.

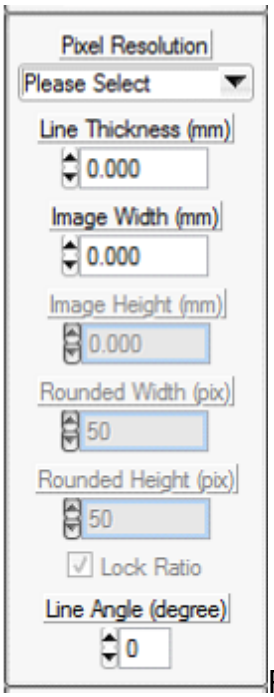


Gradient Pattern: Sets the pattern to draw; options available are line, rectangle, rounded rectangle, and oval.

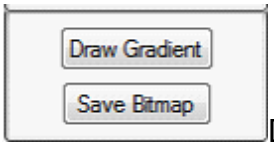
Gradient Direction: Sets the direction of the Gradient drawn; options available are dark to light and light to dark.



Min Pixel Value: Sets the darkest value that will exist in the drawing.
Max Pixel Value: Sets the lightest value that will exist in the drawing.
Levels Used: Returns the number of colors used to create the drawing.

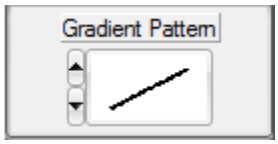


Pixel Resolution: Sets the conversion factor for converting pixels to mm, this value is specific to the resolutions available on the SF-100.
Line Thickness: Sets the thickness in millimeters for the gradient to be drawn.
Image Width: Sets the overall width of the drawn image.
Image Height: Sets the overall height of the drawn image.
Rounded Width: Sets the width of the round corners of the rounded rectangle.
Rounded Height: Sets the height of the rounded corners of the rounded rectangle.
Lock Ratio: Sets whether the Rounded Width: Rounded Height ratio is locked.
Line Angle: Sets the rotation degree of the line.

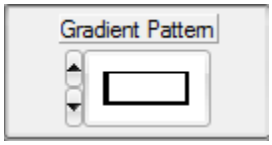


Draw Gradient: Retrieves the set parameters and draws to the canvas.
Save Bitmap: Saves the image on the canvas as a 24-bit bitmap file.

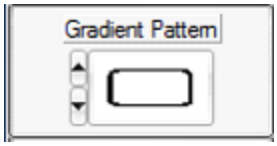
Gradient Pattern Options
There are four patterns available within the GS Draw program: line, rectangle, rounded rectangle, and oval.



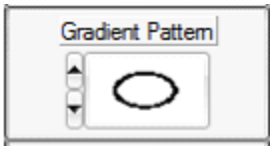
Line: A line will be drawn with a height equal to “Line Thickness”, width equal to “Image Width”, and rotation equal to “Line Angle”.



Rectangle: A rectangle will be drawn with a height equal to “Image Height”, width equal to “Image Width”, and gradient line thickness equal to “Line Thickness”.



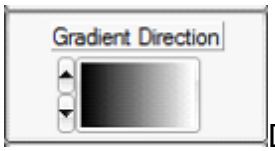
Rounded Rectangle: A rounded rectangle will be drawn with the same dimensions as the rectangle. The rounded corners will be drawn with a pixel height of ”Rounded Height” and a pixel width of “Rounded Width”.



Oval: An oval will be drawn with a height equal to “Image Height”, width equal to “Image Width”, and gradient line thickness equal to “Line Thickness”.

Gradient Direction Options

There are two gradient direction options available within the GS Draw program: dark to light and light to dark.

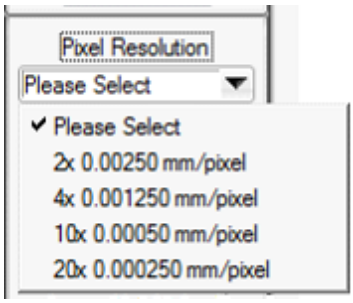


Dark to Light: The gradient drawn will start with “Min Pixel Value” and increase to “Max Pixel Value” creating a gradient the size of “Line Thickness”.

Light to Dark: The gradient drawn will start with “Max Pixel Value” and decrease to “Min Pixel Value” creating a gradient the size of “Line Thickness”.

Pixel Resolution Options

The pixel resolutions available are based on the reduction optic availability of the SF-100. There are for options available within the GS Draw program: 2x, 4x, 10x, and 20x.



2x – Creates a draw ratio of 0.00250 mm/pixel

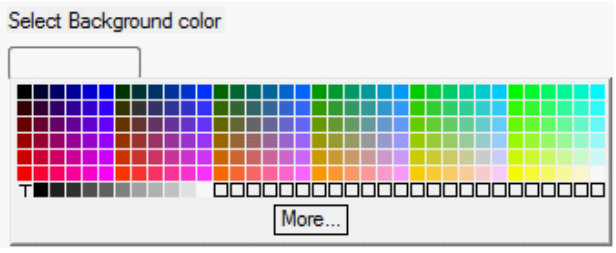
4x – Creates a draw ratio of 0.001250 mm/pixel

10x – Creates a draw ratio of 0.000500 mm/pixel

20x – Creates a draw ratio of 0.000250 mm/pixel

Canvas Background Options

The draw canvas background found in GS Draw defaults to white, but is configurable. The draw canvas background can be set to any color available in a 24-bit color palette.



Select Background color

The background color control is activated by right clicking anywhere in the preview canvas. Left clicking on the color control will display the color palette. Any color may be selected for the background color.

Steps to Create a Drawing

1. Set background if desired (this step can be done at any time)
2. Set desired “Canvas Width” and “Canvas Height”
3. Set desired “Gradient Pattern”
4. Set desired “Gradient Direction”
5. Set “Min Pixel Value” and “Max Pixel Value”
6. Set “Pixel Resolution”
7. Set “Line Thickness”
8. Set “Image Width”
9. Set “Image Height” (this parameter is not needed for line)
10. Set “Rounded With” (this parameter is not needed for line, rectangle, oval)
11. Set “Rounded Height” (this parameter is not needed for line, rectangle, oval)
12. Set “Line Angle” (this parameter is not needed for rectangle, rounded rectangle, oval)
13. Click “Draw Gradient” (this will display the drawing on the canvas)
14. Click “Save Bitmap” to save a copy of the drawn image

INTELLIGENT
MICRO PATTERNING, LLC

Part XII

12 Common Problems & Solutions

Unit Doesn't Turn On

- Power may be disconnected. Verify power cord is plugged into wall outlet.
- Check fuse it may be blown or missing. If needed, replace only with fuse supplied by Intelligent Micro Patterning.

Lamp Doesn't Turn On

- The supplemental cover interlock switches may be open. Verify that the system and lamp access covers are in place.
- The lamp usage may have exceeded the 1100 hour limit. This would have been indicated by a warning message in the Lamp Control program. See above lamp replacement procedure.
- Ensure that the fans are turning when the unit is powered on and airflow is directed outward.
- Make sure that all ventilation areas around the unit are open and allow for proper air flow.
- Verify that all cables coming out of the SF-100 are secure and plugged into the computer
- Verify that there is a green light next to the COM port in the "Lamp Control" tab.

No Image Appears at Substrate

- Check the Data Port Cable connection to see if it is loose.
- Check to see the computer has monitors set to the correct display mode.
- Make sure you clicked "Draw" after loading the artwork
- Make sure the stage is set to the correct focal height

Projected Image is Mirrored From Image on Computer Screen

- To correctly orient the projected image for exposure, flip the image using the "Bitmap Controls ".

Image is Not Exposing

- Image may not be projecting onto the substrate. Verify that data cable is attached from the

computer to the SF-100 Unit.

- Exposure time may be too short. Increase exposure time.
- Ensure that there is a green light next to the COM port in the "Filter Controls" section of the main panel
- Ensure that the exposure filter is moving out of the optical path during exposure using the UV meter supplied with the spare parts kit. Correct operation is indicated by high levels of UV detected by the meter during the substrate exposure.
- The photo-resist or developer may be beyond its expiration date or been exposed to light or heat prior to use on substrate. Verify the photo-resist and developer is within its usable lifetime and has been stored properly.
- Other processes to check include the coating, baking, and developing part of the photo-imaging process.

Image Appears to Be Overexposed

- Exposure time may be too long. Reduce exposure time.
- Verify that all covers are in place on the SF-100 Unit. Failure to have all covers in place may result in stray light from the optical path being projected onto the substrate.

INTELLIGENT
MICRO PATTERNING, LLC

Part XII

13 Specifications

The following section provides technical information about the SF-100 XPRESS/XCEL:

Input Power: 100-120/200-240 VAC 50/60 Hz

Input Current: 3.3A (100-120 VAC)/1.6A (200-240 VAC)

Dimensions: 27.0” W x 59.0” D x 38.5” H (dimensions vary with customization)

Weight: 250 lbs (79.5kg) (weight varies with customization)

Operational Temperatures: 41 to 82 deg F (5 to 28 deg C)

Operational Humidity: 30-50%, non condensing (For effective resist processing)

Regulatory: Conforms to applicable CE directives and Norms

The following section provides technical information about the SF-100 XTREME:

Input Power: 100-120/200-240 VAC 50/60 Hz

Input Current: 3.3A (100-120 VAC)/1.6A (200-240 VAC)

Dimensions: 27.0” W x 59.0” D x 38.5” H (dimensions vary with customization)

Weight: 250 lbs (79.5kg) (weight varies with customization)

Operational Temperatures: 41 to 82 deg F (5 to 28 deg C)

Operational Humidity: 30-50%, non condensing (For effective resist processing)

Regulatory: Conforms to applicable CE directives and Norms

Part XIV

14 Corporate Contact Information

The following contact information should be used if there are any questions on the materials contained in this manual:

Intelligent Micro Patterning, LLC
735 Arlington Ave N.
St. Petersburg, FL 33701
(T) 727-522-0334
(F) 727-522-3896
info@intelligentmp.com
www.intelligentmp.com