
THORLABS

**LFS4100
Fiber Splicer**

User Guide



 vytran®

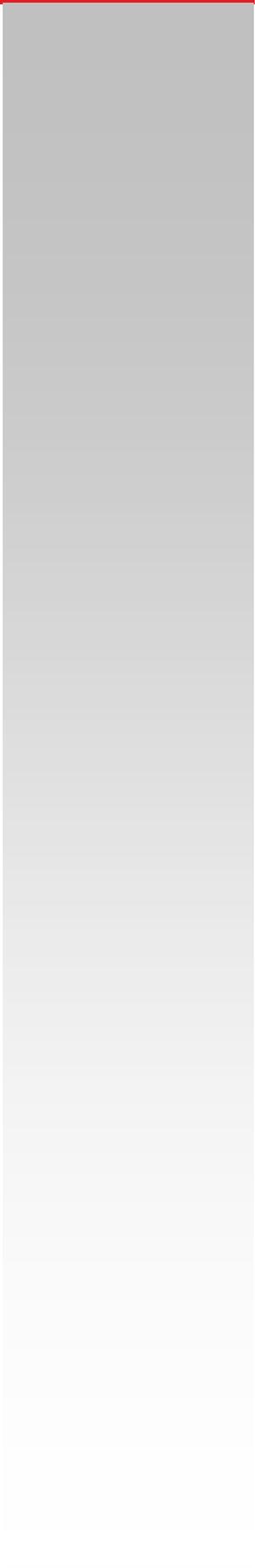


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Chapter 1 Warning Symbol Definitions

Below is a list of warning symbols you may encounter in this manual or on your device.

Symbol	Description
	Direct Current
	Alternating Current
	Both Direct and Alternating Current
	Earth Ground Terminal
	Protective Conductor Terminal
	Frame or Chassis Terminal
	Equipotentiality
	On (Supply)
	Off (Supply)
	In Position of a Bi-Stable Push Control
	Out Position of a Bi-Stable Push Control
	Caution: Risk of Electric Shock
	Caution: Hot Surface
	Caution: Risk of Danger
	Warning: Laser Radiation
	Caution: Spinning Blades May Cause Harm

Chapter 2 Safety



WARNING



The filament in the LFS4100 furnace generates intense light when it is in operation. It is strongly advised that the user NOT look directly at it during splicing or tapering operations.



CAUTION: HOT SURFACE



The furnace gets extremely hot when the filament turns on. Touching the furnace immediately after the filament has been on for a few seconds, such as after a splicing or tapering operation, is **STRONGLY ADVISED AGAINST**.



WARNING



The fiber handlers and the splice head can exert a fair amount of force as they move from side to side. It is strongly advised that users NOT put their fingers between them, or between the fiber handlers and the slot end walls, while the machine is in operation.



WARNING



Similarly, the camera tower can generate a fair amount of force as it moves forward and back, and up and down. It is strongly advised that users NOT put their fingers between it and the furnace or mirror tower while the machine is in operation.



CAUTION



Be sure your electrical power and gas supplies meet the criteria detailed in Chapter 9.

Chapter 3 Description

3.1. Introduction

Thorlabs' Vytran® LFS4100 is a dedicated process tool for splicing standard, large-diameter, and specialty fibers. Designed for volume production of fiber assemblies, it is intended for manufacturers that want the splicing performance of Vytran's proven filament fusion, multi-function splicing, and glass processing products from a stand-alone, easy-to-use tool.

The LFS4100 is designed to perform high-quality fusion splicing of fibers with claddings from Ø125 µm to Ø1.25 mm. The system consists of a filament-based heater, precision stages with multi-axis control, a microscopic high-resolution CCD imaging system, and a desktop computer. The filament heater has a wide temperature tuning range that extends up to 3000 °C, which makes it possible to fuse and process various fiber types and sizes. The multi-axis stages precisely control and align the fibers for high quality splicing. The imaging system displays a magnified fiber image with sub-micron resolution; the camera can display views of both the fiber sides and fiber ends. Using these images, the XY and rotation stages automatically manipulate the fibers to achieve optimum positioning and ensure high-quality, low-loss splicing. The LFS4100 also has the ability to rotate fibers, making it possible to align PM fibers, eccentric-core fibers, and non-circular fibers.

3.2. Filament Fusion Splicing

Thorlabs' unique filament fusion technology provides a consistent, reliable method of making high-strength, low-loss splices. Precision control of the fusion process is achieved by purging the splice region with an inert gas and using a resistive graphite, tungsten or iridium filament to supply the thermal input necessary for fiber fusion. Because the fusion heat source is isolated for the environment, filament fusion splicing is not dependent upon ambient conditions. The controlled conditions inside the system in combination with constant power control ensure repeatable performance splice after splice.

3.3. Features

- Automated splice head
- XY alignment blocks with rotary capability
- Camera tower with ring illuminator.

3.4. LFS4100 System and Accessories

- | | |
|---------------------------|--|
| 1. LFS4100: | Splicing system |
| 2. Desktop Computer: | Dell |
| 3. External Power Supply: | Dual voltage power supply and cable |
| 4. Vacuum Pump: | Vacuum pump LV-125A for vacuum V-groove (alternative model supplied for 230V markets.) |
| 5. Gas Tank Regulator: | Regulator for argon tank (Note: European DIN 477 Number 6 fittings are supplied in European markets. An adapter may be required to allow connection of the supplied CGA-580 output port to the gas tank fittings in other areas or countries). |
| 6. 1/8" PTFE Gas Line: | Gas line for gas tank regulator |
| 7. RS-232 Comm. Cable: | 9-pin D-sub cable for RS-232 communication |
| 8. Camera Cable: | 6-pin IEEE-1394 firewire cable |
| 9. Tool kit: | Allen wrenches for filament and V-groove replacement |
| 10. FHB inserts: | Top and bottom inserts for fiber holding blocks (Sold Separately) |
| 11. Filament Assemblies: | Filament heating elements and protective shrouds (Sold Separately) |

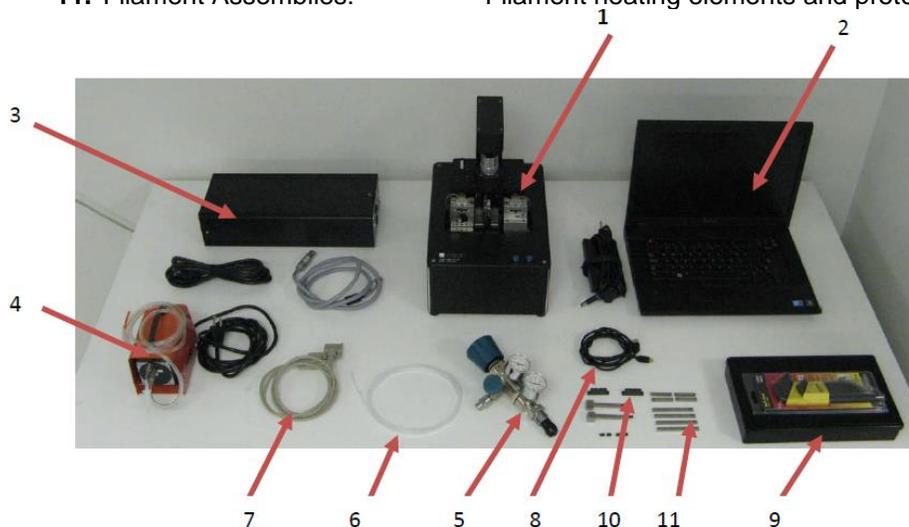


Figure 1 LFS4100 System and Components

3.5. System Overview

The LFS4100 splicing system has three basic components: a splicing workstation, a desktop computer, and a gas supply. The splicer workstation is illustrated in Figure 2:



Figure 2 LFS4100 Splicing Workstation

3.5.1. External Workstation Connections

The splicer workstation is the main component of the LFS4100 system. The PC and gas supply, as well as peripheral components such as an optical power meter, are connected to its back panel as illustrated below.

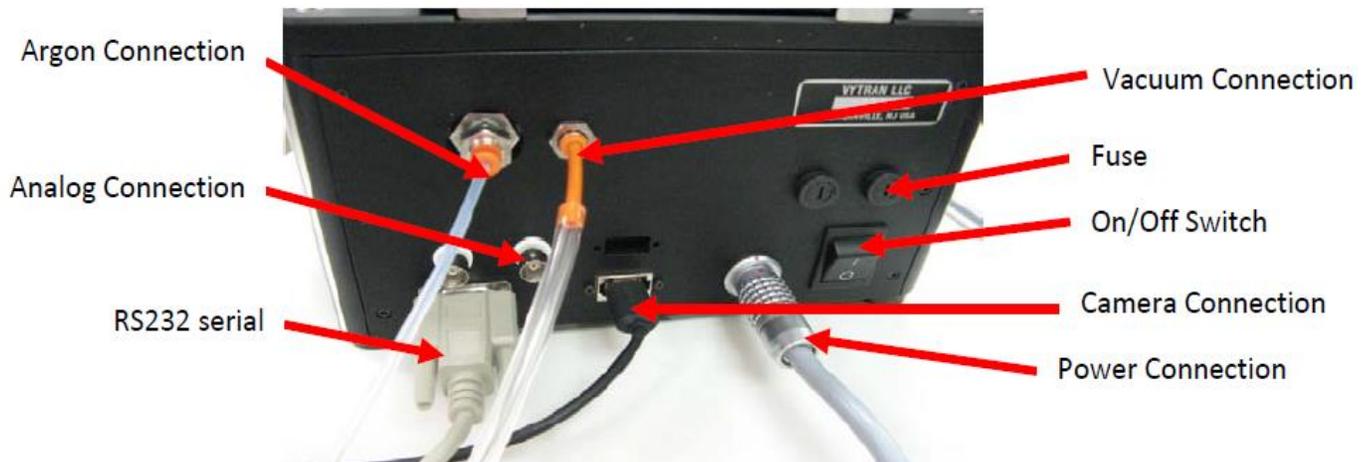


Figure 3 Splicing Workstation Connections

Power:

The LFS4100 workstation is powered from an external dual-voltage supply. Connection is made via a 5-pin round connector.

Communication:

PC – LFS4100 Control communication:	RS-232 9-way D-Sub connector, Connect to Com 1 on the PC
Camera - PC:	IEEE-1394 6-pole connection, Connect to IEEE1394 4 pole on PC

Note: The computer and the LFS4100 have to be powered off before connecting and disconnecting the camera firewire cable between the LFS4100 and the computer.

Analog Outputs: 2 BNC connectors - Analog 1 and Analog 2

Gas:

Argon:	1/8" push-fit connector
Vacuum:	5/32" push-fit connector

3.5.2. Fiber Holding Blocks

The fiber holding blocks are used for holding, positioning, and moving the fibers during the splice process implemented on the LFS4100. Fiber alignment can be performed using either the edges of the fibers or their cores. Standard fibers require only an XY alignment, while specialty fibers may require both XY alignment and rotational alignment. The rotation function permits each fiber to be rotated by up to 200 degrees. This is used to align the stress members of PM fiber, the cores of eccentric-core fiber, and the surface features of non-circular fiber.

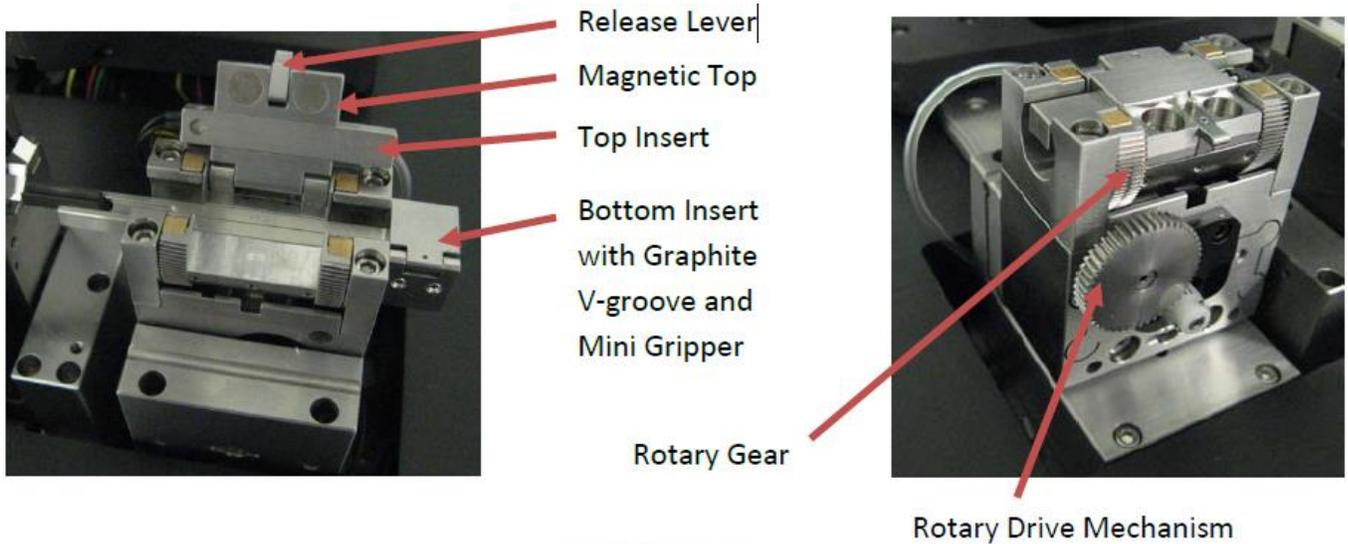


Figure 4 Fiber Holding Blocks

3.5.3. Fiber Holding Block Inserts

The LFS4100 fusion splicer requires fiber holder inserts to be placed in the fiber holding blocks in order to clamp the fibers during the splicing process. A top and bottom insert (sold separately) is required for each of the two fiber holding blocks. A variety of fiber holder inserts are available for different fiber diameters. To see the available fiber holder inserts, see the selection chart in Chapter 8. In addition to the standard sizes, custom inserts may be specially designed for various applications. Contact Thorlabs for more information.

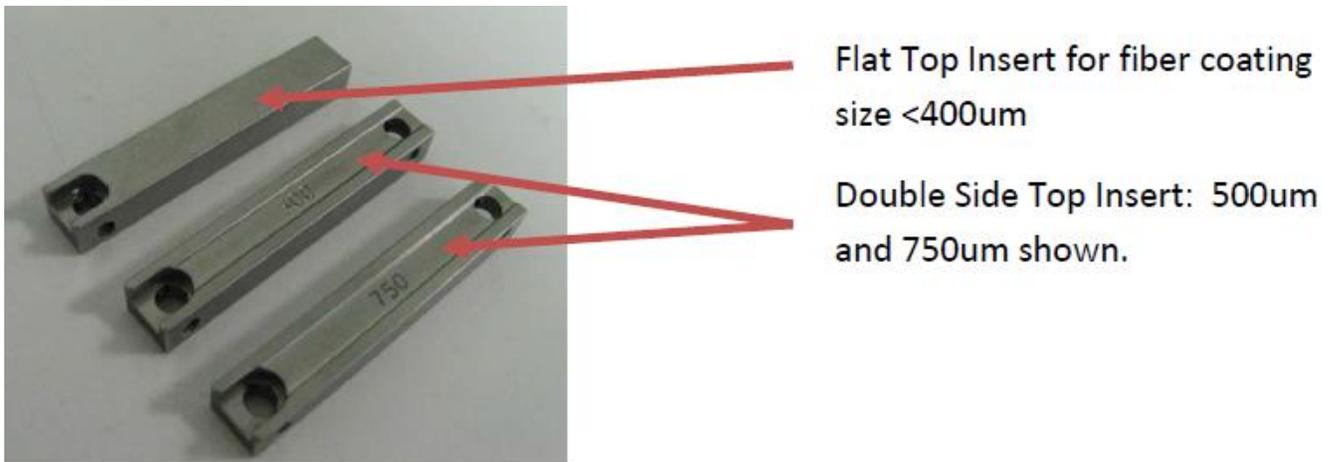


Figure 5 Fiber Holder Inserts

3.5.4. Fiber Holder Transfer Inserts (Bottom Inserts for Fibers $\leq \text{Ø}1047 \mu\text{m}$)

There are two types of bottom inserts that are compatible with the LFS4100 fusion splicer. The bottom inserts for fibers with cladding or buffer diameters up to 1.047 mm (indicated with Item #'s starting with VHF) are transfer

inserts; they allow for a single fiber to be transferred between the Vytran FPS300 Fiber Preparation Station, LDC400 Series of Fiber Cleavers, and LFS4100 Splicer without loss of positional reference. For example, a fiber can be placed in a transfer insert and cleaved using the LDC400 cleaver. Then, the entire transfer insert can be placed in the LFS4100, and it will already be roughly aligned for splicing. This process works because the transfer inserts are precisely located within each Vytran system and the VHT1 magnetic lid on the transfer inserts prevents axial movement of the fiber during transport. These transfer inserts include vacuum holes that provide a small suction force to hold the fiber in place.

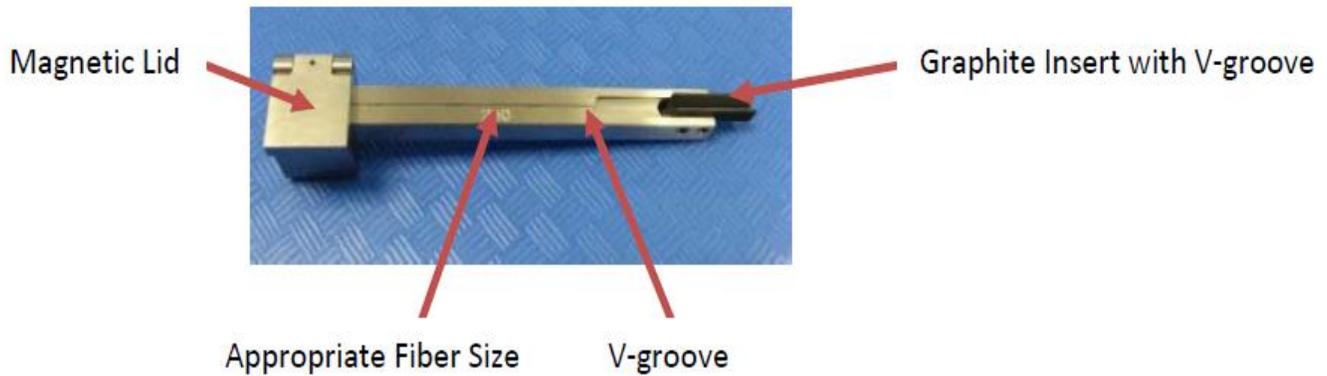


Figure 6 *Fiber Holder Transfer Bottom Insert*

3.5.5. Splice Head

The splice head employs a filament assembly that can be changed if a different filament size is desired. This assembly is held down by two filament clamps. In addition to holding down the filament assembly, the filament clamps also serve to limit the influx of room air into the splicing area, as they have protrusions that cover most of the filament cavity.

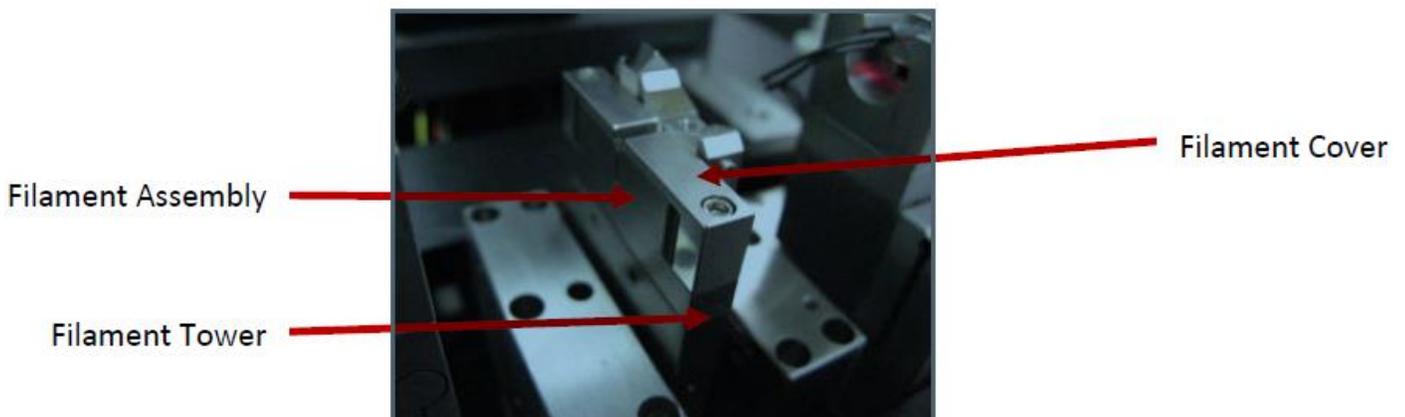


Figure 7 *Splice Head with Filament Assembly*

3.5.6. Filament Assembly

Thorlabs supplies filaments as part of a filament assembly, as shown in the Figure 8. These assemblies contain a graphite, tungsten, or iridium filament within a protective shroud. One filament assembly is required to operate the LFS4100 fusion splicer (one included, others sold separately).

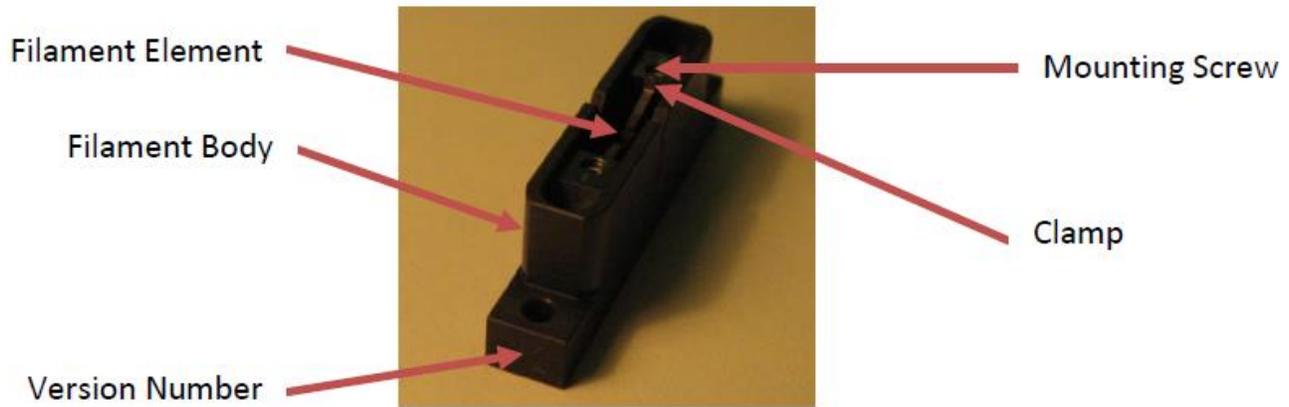
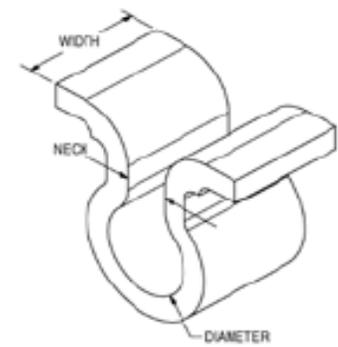


Figure 8 Filament Assembly

3.5.7. Filaments

The filaments are omega-shaped resistive heaters. Proper filament selection and splice parameters are essential for optimum splice performance. Graphite filaments are useful for a wide range of applications. They are capable of reaching the high temperatures required for large diameter silica splicing. Tungsten filaments offer narrower heat zones and reach temperature very quickly making them ideal for splicing highly doped fibers and structured fibers where long splice duration could cause significant diffusion or collapse. Iridium filaments can be operated at the low temperatures necessary to process soft glasses.



Filament Item #	Filament Material	Fiber Cladding Diameter (Min / Max)
FTAV2	Graphite	80 μm / 250 μm
FTAV4		125 μm / 600 μm
FTAV5		250 μm / 1000 μm
FTAV6		400 μm / 1300 μm
FWAV1	Tungsten	≤200 μm
FRAV1	Iridium	≤200 μm
FRAV3		≤400 μm
FRAV5		250 μm / 1050 μm

Table 1: Filament Assembly Specifications

3.5.8. Mirror Tower

The mirror tower holds two sets of mirrors and an LED. The first set of mirrors makes it possible to view the sides of the fibers. They provide the front view and back view, respectively. The second set of mirrors makes it possible to view the ends of the fibers. The LED provides backlighting for viewing the ends of the fibers.

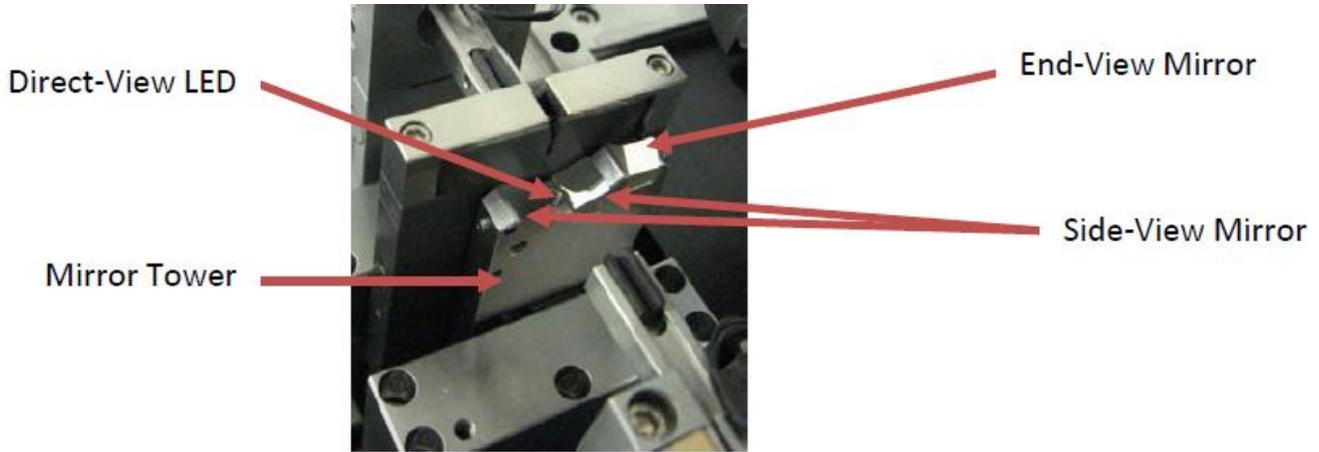


Figure 9 Mirror Tower

3.5.9. Imaging System

The LFS4100 splicing station comes with an automated camera assembly for imaging the fibers. This tower can be moved forwards and backwards as well as up and down. It is equipped with a ring illuminator that provides backlighting for the front and back views of the fiber. The camera objective may be replaced if a larger field of view is desired.

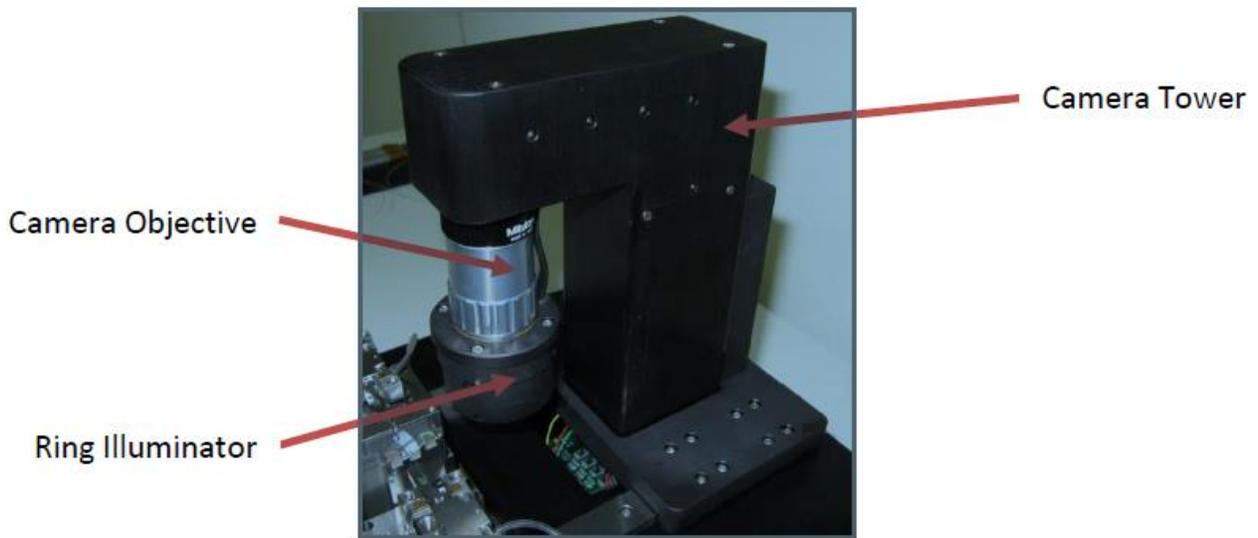


Figure 10 Imaging System

Chapter 4 Set-Up

1. Unpack the desktop computer and set it up using the included instructions from the computer manufacturer. If the operator is right handed, the computer should be set up to the right of the operator. If the operator is left handed, the computer should be set up to the left of the operator.
2. Unpack the LFS4100 and place it on a workbench. Make sure not to damage any components of the LFS4100 during handling of the workstation. Lift by the built-in handles on the side of the system. Remove the labeled transport block from the base of the camera tower.
3. Connect the external vacuum pump:
 - a. Connect the muffler to the top connector of the vacuum pump
 - b. Using the included tube, connect the bottom connector on the vacuum pump, labeled "VAC," to the connection labeled "VACUUM" on the back of the LFS4100.

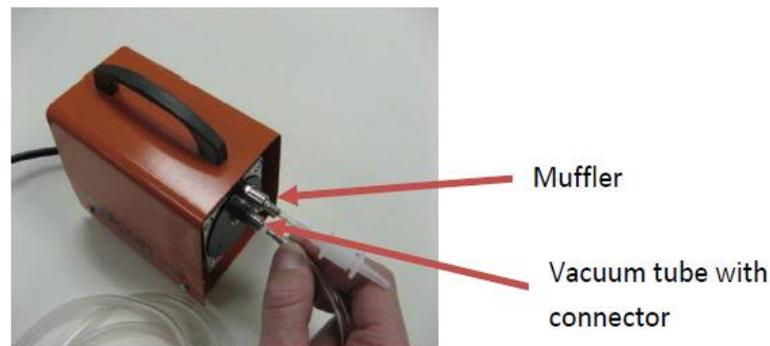


Figure 11 External Vacuum Pump for Bottom Fiber Holder Inserts

4. Use the included IEEE-1394 firewire cable to connect the camera to the port on the LFS4100 labeled "CAMERA" (6-pin side) and to the firewire port on the computer (4-pin side).

Note: The computer and the LFS4100 have to be powered off before connecting and disconnecting the camera firewire cable.
5. Use the RS-232 serial communication cable to connect the port labeled "SERIAL COMMS" on the back of the LFS4100 to the computer's serial communication connector (see instructions from computer manufacturer). Tighten the screws on both sides of the cable.
6. Install the supplied CGA-580 gas regulator to the gas tank as shown below, using the manufacturer-supplied operating and safety instructions. (**NOTE:** a European DIN 477 Number 6 fitting is supplied as required in European markets. An adaptor may be required to allow connection of the supplied CGA-580 output port to the gas tank fittings in other areas or countries).

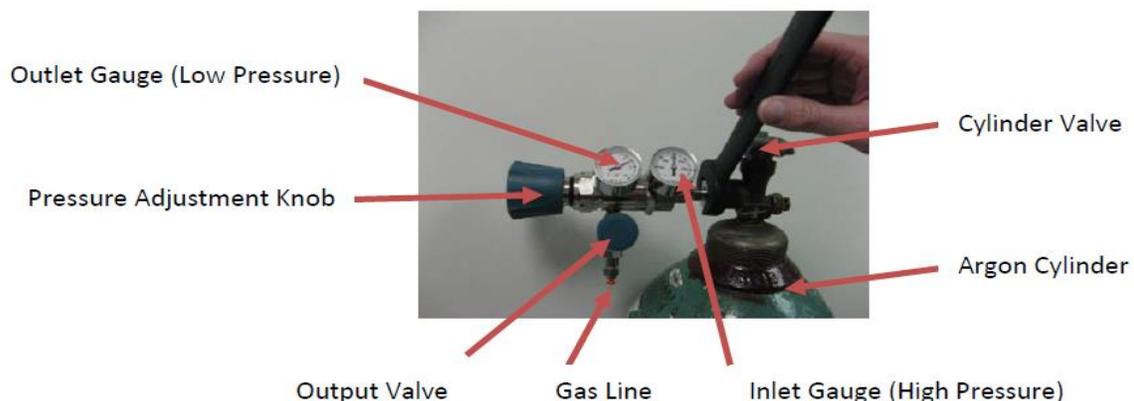


Figure 12 Gas Tank Regulator and Gas Line

7. Connect the gas line to the back of the LFS4100. Make sure to push the gas line all the way into the fitting. To check if the line is connected properly, pull lightly on it to make sure it is held by the fitting.
8. Connect the ferrite end of the DC-power cable to the port on the back of the LFS4100 labeled "POWER". Plug the other end of the cable into the DC power supply. Be sure to align the red dot on the plug with the red dot on the receptacle.



Figure 13 DC Power Cable Connections

9. Connect the AC power cord to the DC power supply and a power source of 110/230 VAC, 47-63 Hz.
10. If a cooling jacket is to be fitted to the splice head (optional), follow the set-up instructions provided with the cooling system.

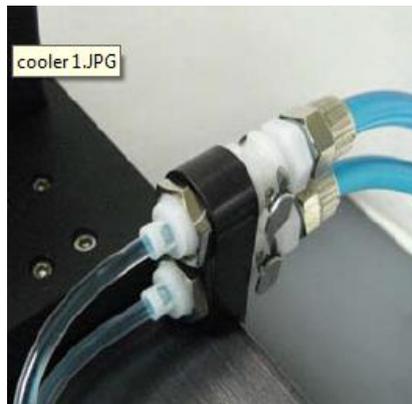
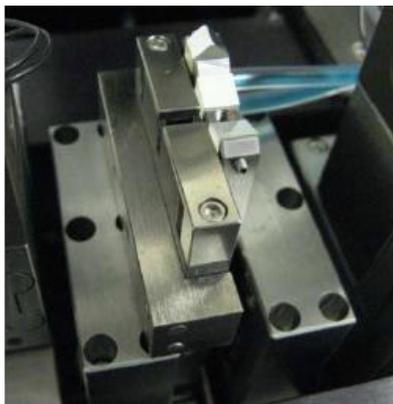


Figure 14 Splice Head Cooling System Connected to LFS4100 (optional)

Chapter 5 Software Interface

The software interface involves a graphical user interface, or GUI, and an SQL database. The GUI is the main window when working on the LFS4100. It has different menus and toolbars that are explained in this chapter. The buttons are described from top to bottom. The graphical user interface is illustrated below.

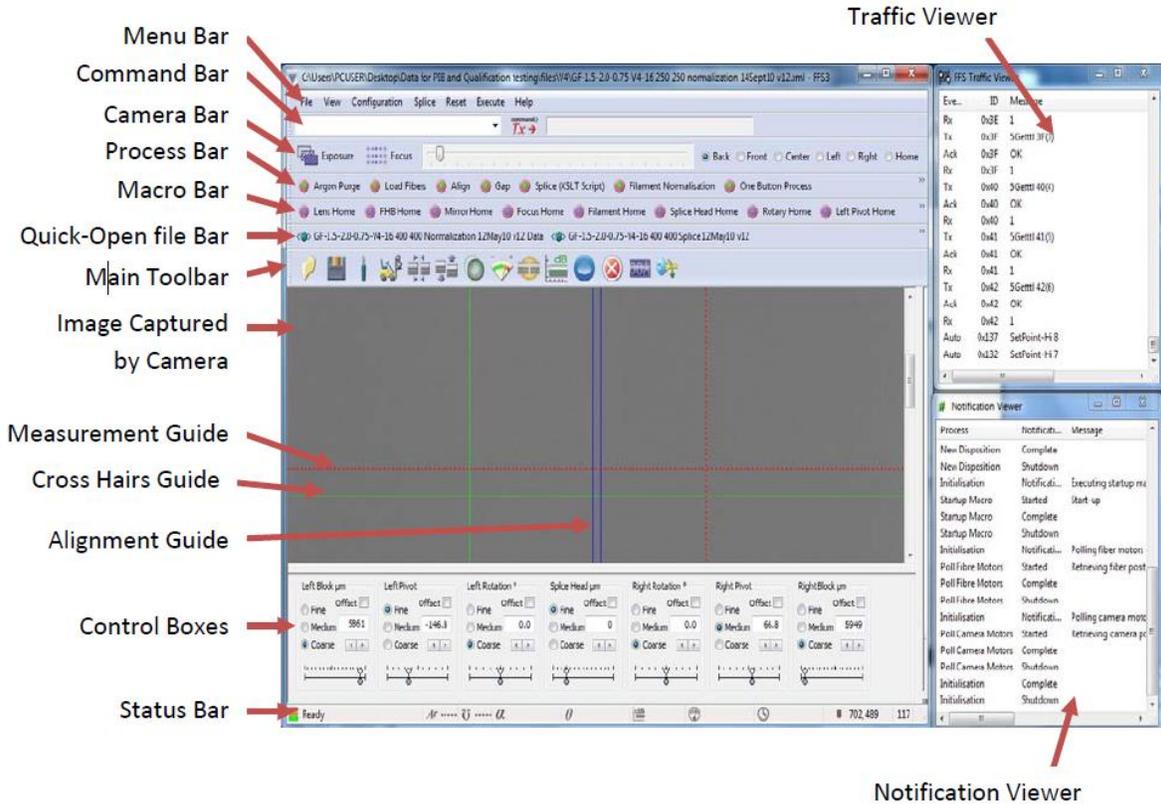


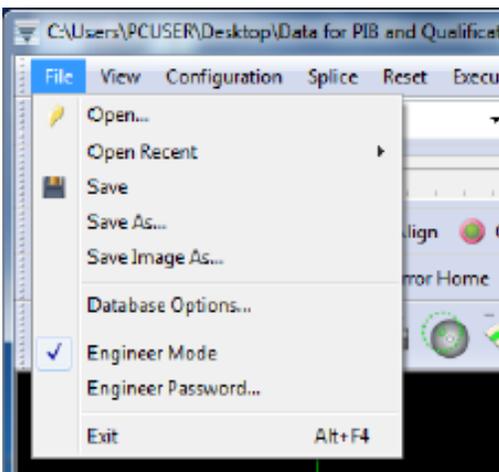
Figure 15 LFS4100 Graphical User Interface

The following sections describe each component of the GUI in detail.

5.1. Menu Bar

File View Configuration Splice Reset Execute Help

5.1.1. File



The File menu is structured as shown to the left.

Open: Open a new splice data file.

Open Recent: Show recently opened files.

Save: Save current splice parameters to the current splice data file.

Save As: Save current splice parameters to a new splice data file.



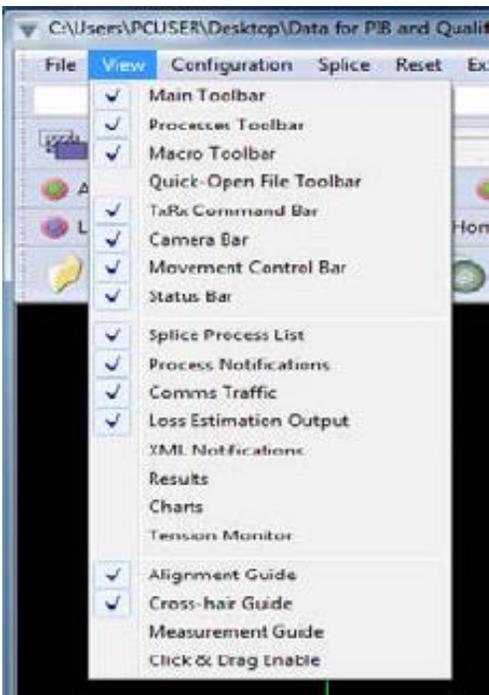
Database Options: Enables or disables the database and resets the database. The database has preconfigured settings that should not be altered.

Engineer Mode: Not yet activated.

Engineer Password: Not yet activated.

Exit: Close the GUI.

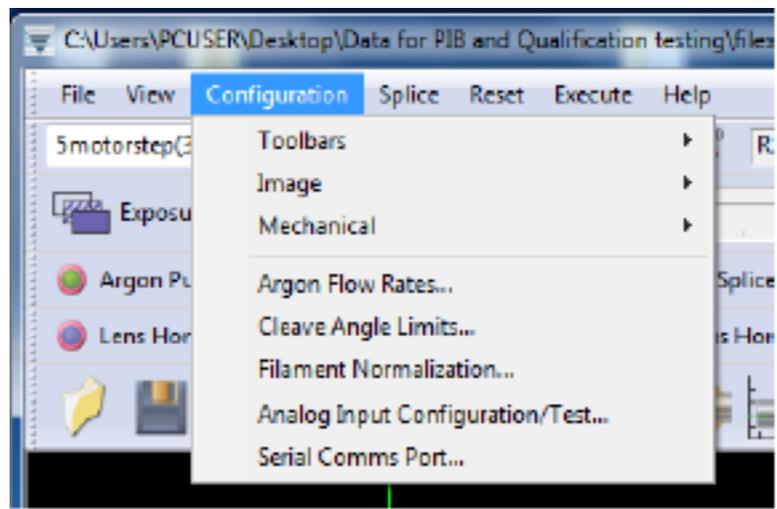
5.1.2. View

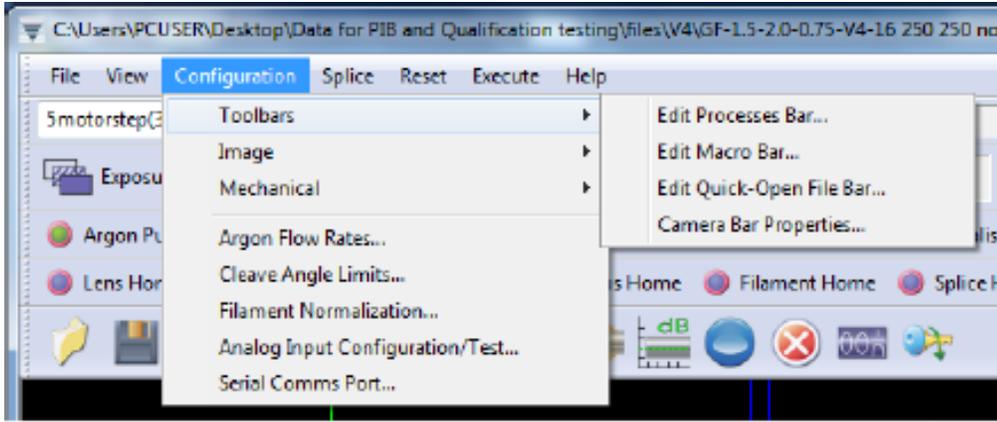


The view menu allows the user to hide or display the various toolbars, data windows, and guides (such as crosshair and alignment guides) associated with the GUI. The Processes Toolbar, Macro Toolbar, and Quick-Open File Toolbar can only be activated if functions are assigned to them. You can assign functions to these toolbars using the Configuration menu.

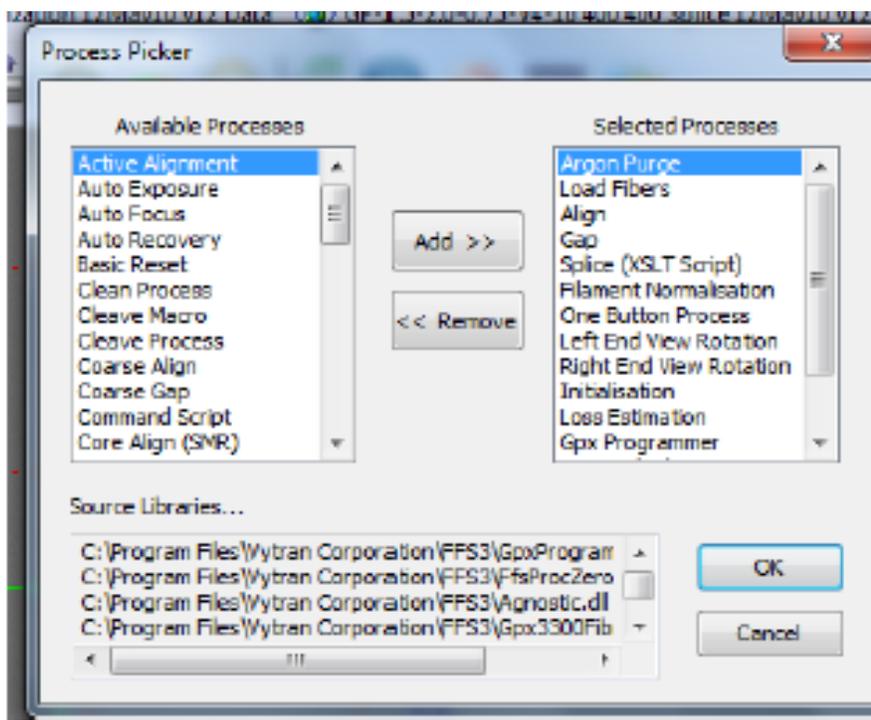
5.1.3. Configuration

The Configuration menu allows the user to edit the properties of the user interface and set the required parameters for the LFS4100 workstation.

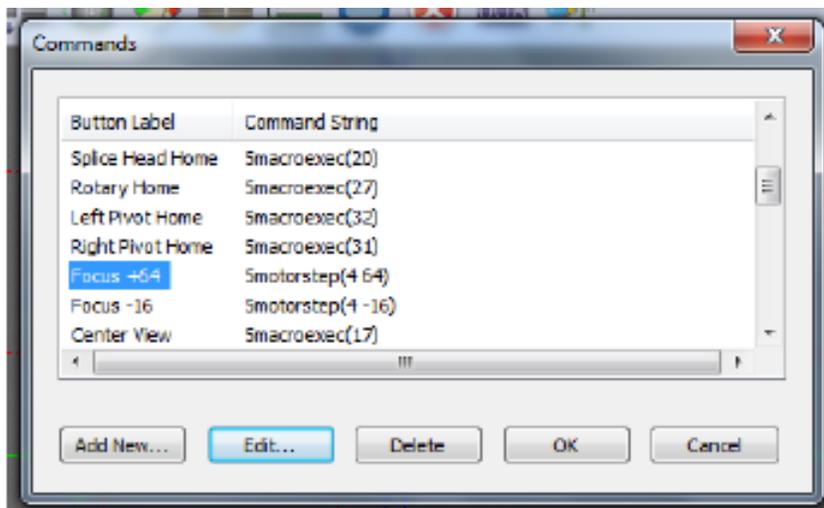




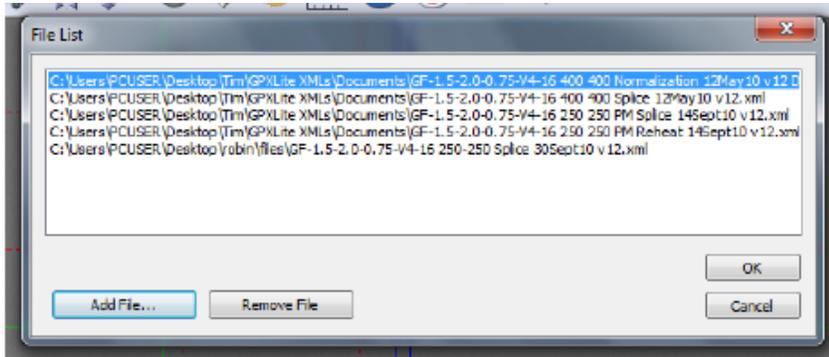
Toolbars: The Process Toolbar, Macro Toolbar, Quick-Open File Toolbar, and Camera Toolbar can be modified through the Toolbars menu.



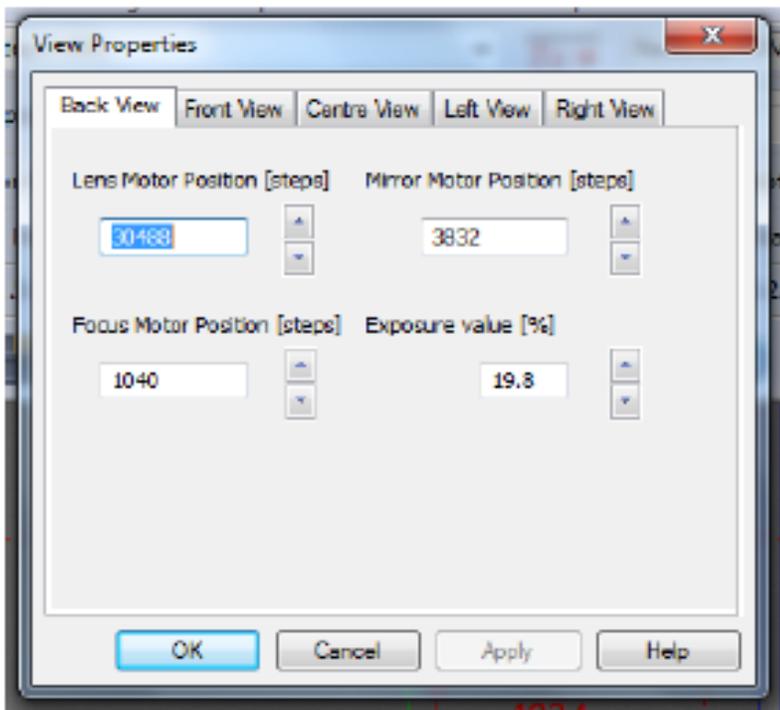
Edit Processes Bar: Allows the user to define which process will be shown on the Processes Toolbar for quick usage. The Selected Processes window includes all the processes which will be shown on the screen.



Edit Macro Bar: Allows the user to define which macro or commands will be shown on the Macro Toolbar.



Edit Quick-Open File Bar: Allows the user to choose which files appear on the Quick-Open File Toolbar. Users can add or remove files from this window.



Camera Bar Properties: Allows the user to edit the properties of each fiber view provided by the camera. Each tab of the View Properties window includes the settings for a different fiber view.

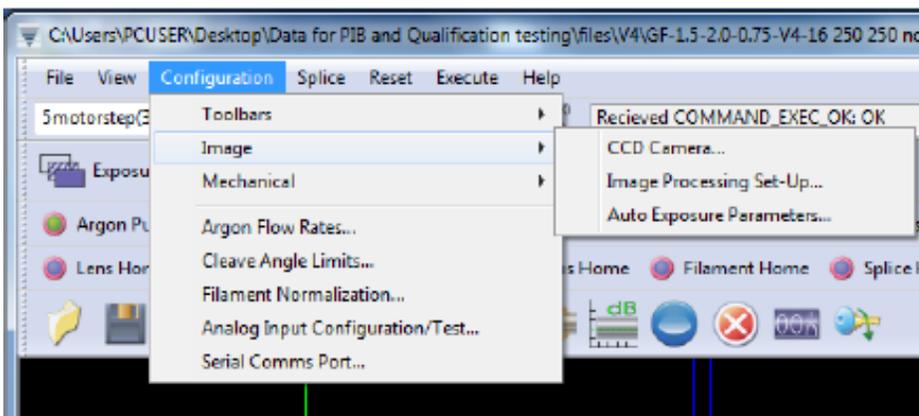
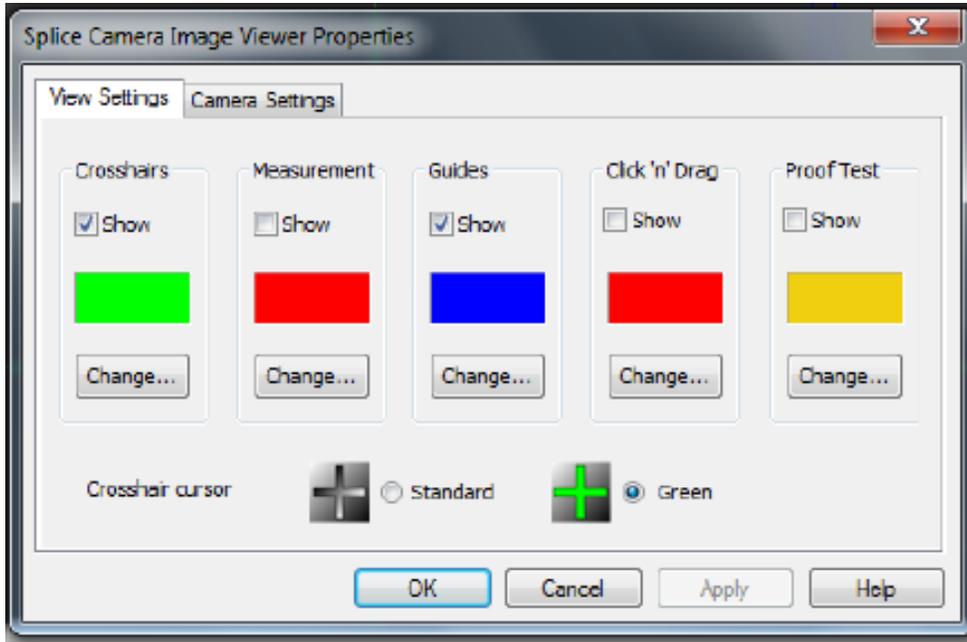
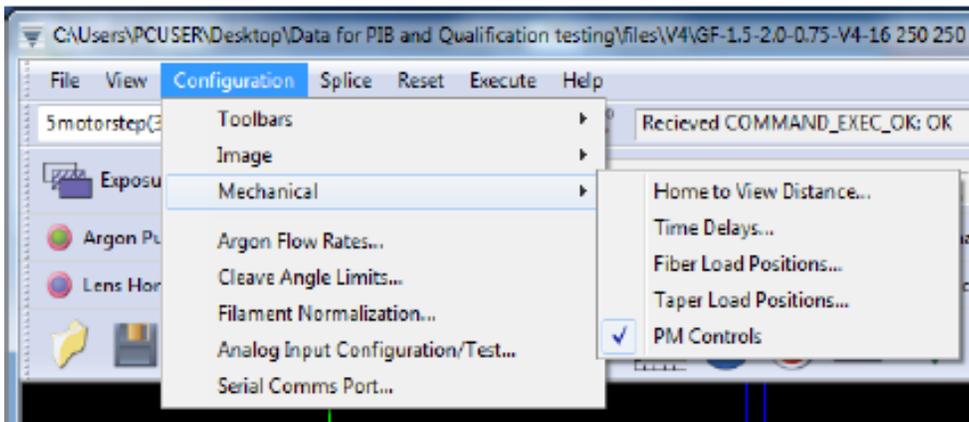


Image: The properties of the CCD imaging system can be modified within the Image menu.



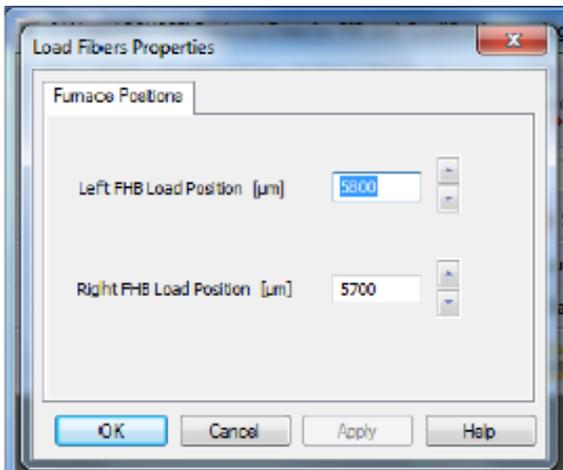
CCD Camera: The view settings within this window allow the user to turn on and off all the cursors on the screen. Options on the Camera Settings tab are pre-set; the user should not change them.



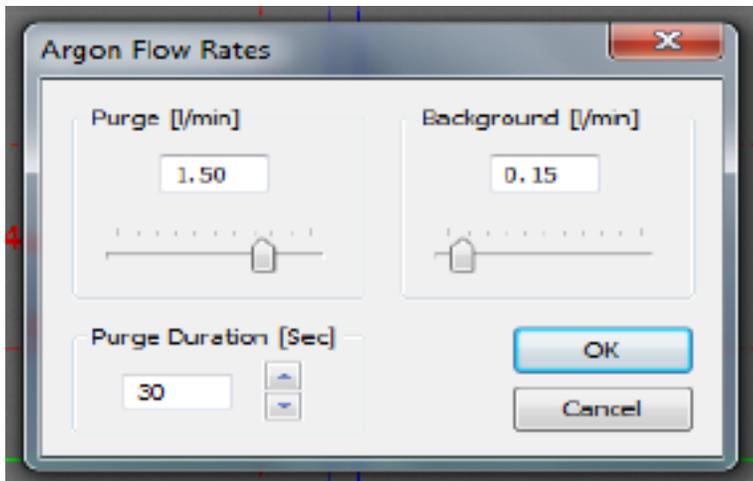
Mechanical: The Mechanical menu includes options for the fiber holding blocks.

Home to View Distance: This option sets the distance between the splice home and the actual viewing position of the splice head.

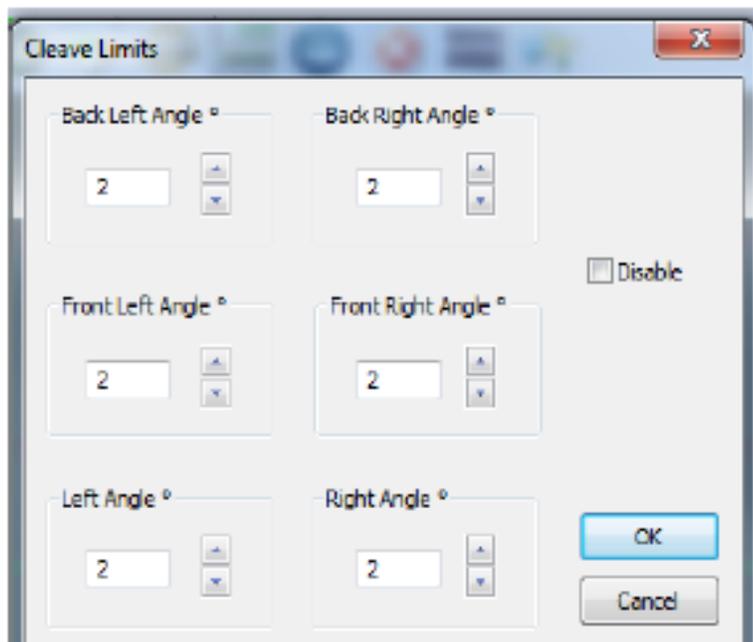
Time Delays: Set by the manufacturer.



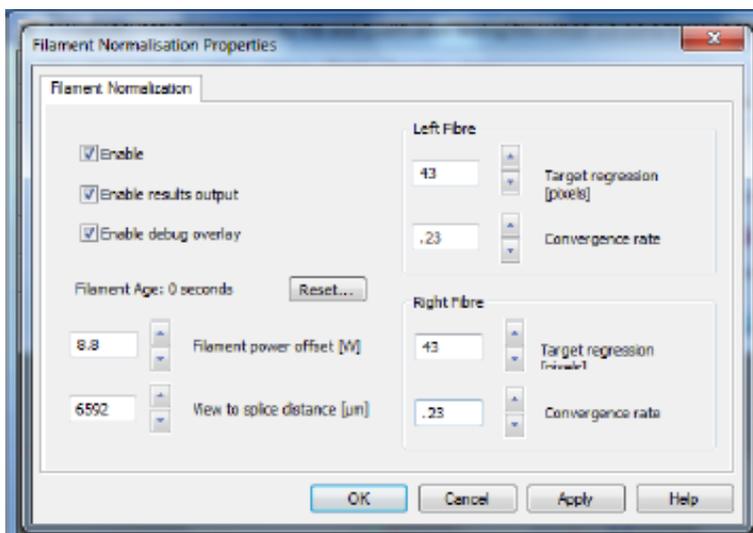
Fiber Load Positions: This window sets the position of the fiber holding blocks when they are ready for fiber loading.



Argon Flow Rates: Three argon flow rate options can be set using this window. The Purge and Background settings are controlled in this window, while the argon flow rate for the splice is set in the Splice Properties window.

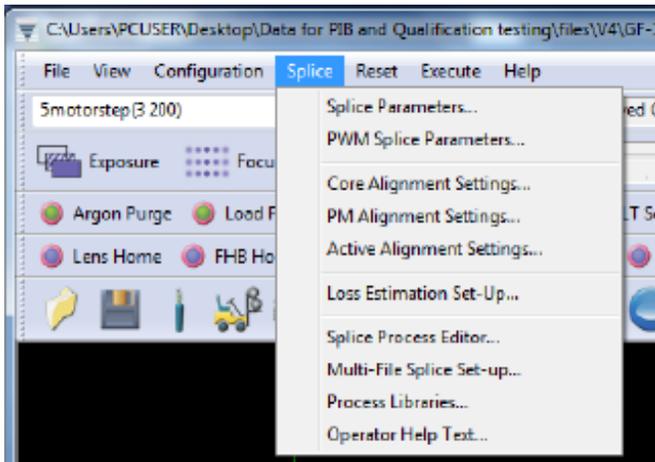


Cleave Angle Limits: The system can measure the cleave angle of the fibers before splicing them together. The user can set the cleave angle limits to reject poorly cleaved fibers.



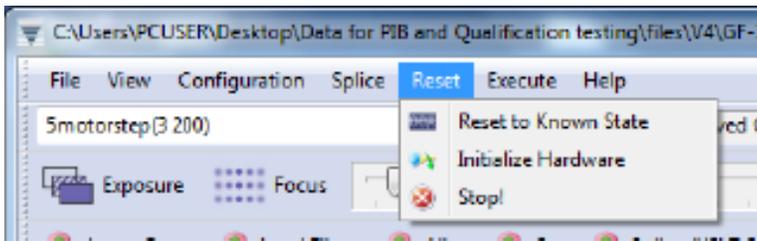
Filament Normalization: The values in this window are set by the manufacturer. The process will be explained in Chapter 6.

5.1.4. Splice



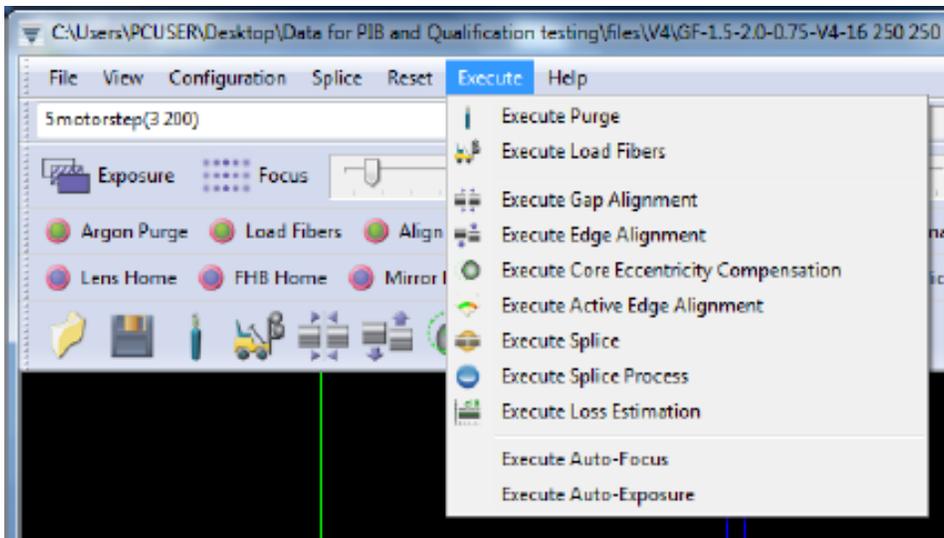
The different splice processes and parameters can be adjusted using the Splice menu. More details about these options will be discussed in Chapter 6.

5.1.5. Reset



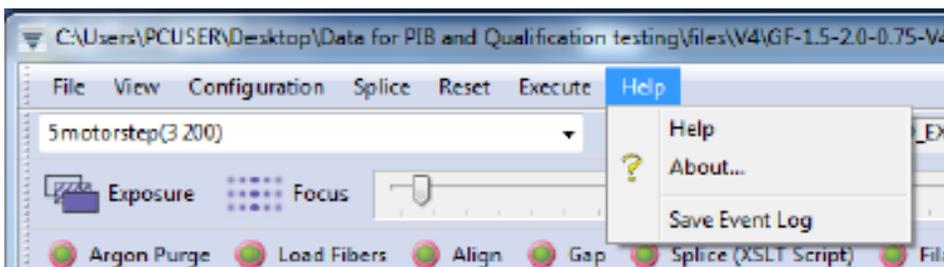
The Reset menu allows the user to initialize, stop, and reset the LFS4100.

5.1.6. Execute



The Execute menu can be used to perform key splicing functions. For descriptions of these functions, see Section 5.7 below.

5.1.7. Help



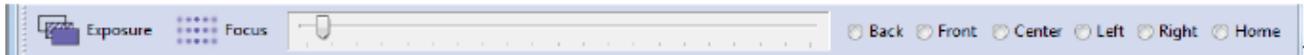
The Help menu provides information about using the LFS4100 and operating the software. It also allows the user to save the event log.

5.2. Command Bar



The Command bar allows the user to directly enter a command to perform motion control using the system's stepper motors. In the example above, the third motor (lens position) is moved forward by 200 steps. Commands are entered into the white window. The window to the right of the Tx button shows the machine code response.

5.3. Camera Bar



The Camera bar includes options for the CCD imaging system.

Exposure: The Exposure button automatically adjusts the image so that the background is the desired brightness. To change the brightness setting, right click the button and click View Properties.

Focus: The Focus button automatically focuses the camera on the fiber. To change the properties of the auto-focus process, right-click the button and click View Properties.

Focus Slider: Next to the Focus button is a slider for manually adjusting the camera focus.

View: Next to the Focus Slider is a row of radio buttons for choosing the camera position. Home is the proper camera position for system storage and manipulation of fibers. Back and Front are two different side views used to align fibers. The Back view is typically used as the referenced view. Left and Right views show the fiber end face. External illumination may be necessary to use this view with certain fiber types.

5.4. Processes Bar

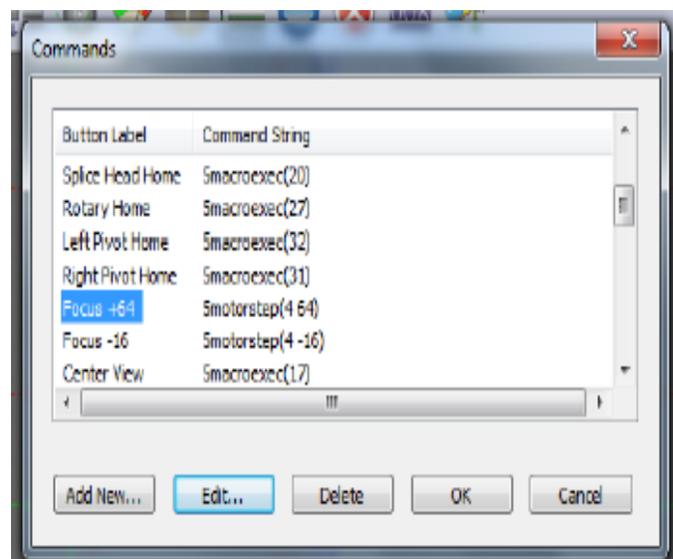


The Processes bar allows the user to execute splice processes such as Align, Gap, and Filament Normalization. Additional processes can be added by right clicking on this bar and selecting Toolbar Properties to access the Process Picker window. In this document and in the GUI, the word “process” is used to denote a machine action that has been programmed using low-level programming language. The actions cannot be changed by the user. This is in contrast to a “macro,” which can be changed (or created) by the user.

5.5. Macro Bar



The Macro bar contains buttons that execute various macros. Again, the word “macro” is used to denote machine actions that the user can change or create from scratch. The Macro bar can be edited by right clicking on an empty space on the bar. The Command window then allows the user to add, edit, or delete the macros shown in the Macro Bar.



5.6. Quick-Open File Bar



The Quick-Open File Bar allows the user to easily load the most commonly used files. To add or delete files on the toolbar, right click on the open space and bring up the File List window.

5.7. Main Toolbar



The illustrated buttons on the toolbar right above the image window execute processes critical to splicing and data management.



Open: This button opens a splice data file. This means that the software loads an XML file containing predefined parameters in preparation for a splice. Splicing systems come preinstalled with basic files (such as an SMF-28 to SMF-28 splice). These files are available in specific filament folders. Be sure to have the corresponding filament installed before using a file.



Save: This command saves the parameters currently in use to an XML file that can be accessed later. If you are using an XML file created by Thorlabs, it is recommended that you perform a Save As command so that the standard file can be referenced in the future.



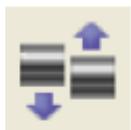
Purge: This button increases the argon flow throughout the unit, removing air and impurities that may contaminate the splice process. You should perform this function at least once every time you turn on the argon supply.



Load Fibers: This button moves the fibers to the splice position using predetermined positions for the fiber holding blocks. You can change these positions by right-clicking on the Load Fibers button.



Gap: This command gaps the fibers, moving them so that the end faces are at the pre-gap distance specified under Splice Parameters.



Alignment: This function finds the edges of the fibers and align them. This will only align the fibers in the current view (front or back). Therefore, it is necessary to repeat the process in a perpendicular view. The alignment process will not work if both edges of each fiber are not visible. In the end view, this process will also rotate the fiber and align it based on the current PM Alignment settings.



Core Alignment: This button aligns the cores of the fibers rather than aligning the fibers using their edges.



Active Alignment: This button aligns the fibers actively using an external light source and power meter. The power meter must be connected to one of the “Analog” ports on the back panel. The analog input reading can be configured under Configuration, Analog Input Configuration with the Channel set to the appropriate port.



Splice Only: This button executes the basic splice process, meaning it sends the lens home (if it has not been done), brings the splice head into position, and executes a splice according to the splice parameters. This process will not attempt to align the fibers; it is useful in the case where the fibers have been manually aligned.



One Button Process: This executes the Splice Routine found under Splice, Splice Process Editor, which generally includes alignment and gapping. The blue button labeled “START” on the front right corner of the LFS4100 has the same function.



Stop: This button stops whatever process is being executed. The blue button labeled “STOP” on the front right corner of the LFS4100 has the same function.



Reset: This button resets the parameters of the LFS4100 to the default values.



Initialize: This button initializes the unit. The system should automatically initialize after the power is on. If the machine is stopped due to any reason, it should be reinitialized by clicking on this button.

5.8. Camera Image

The camera image shown below is a side view (“Front” or “Back”) of a pair of fibers. Front and back views are captured with the help of mirrors on the mirror tower, and feature back-lighting from LEDs in the ring illuminator. Another way to get an edge view is to view the fiber pair straight on. This is accomplished by clicking on Center View in the Macro Toolbar. In this case the fiber will be backlit by an LED in the mirror tower. Finally, the unit is also capable of viewing fibers end-on in “Left” or “Right” view. This is also accomplished with mirrors on the mirror tower, but in this case the illumination comes from light injected into the fibers in the fiber holding block lids.

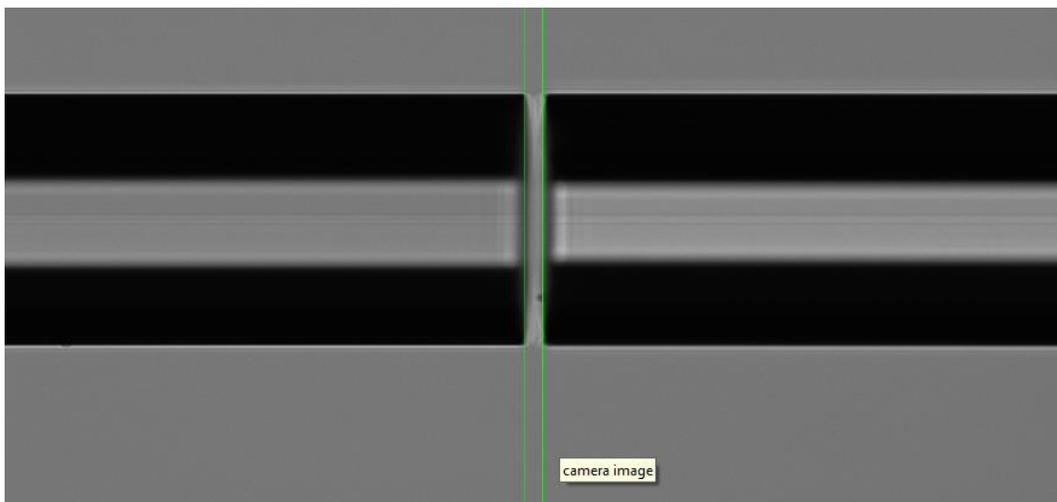


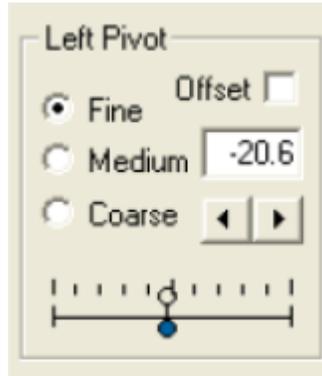
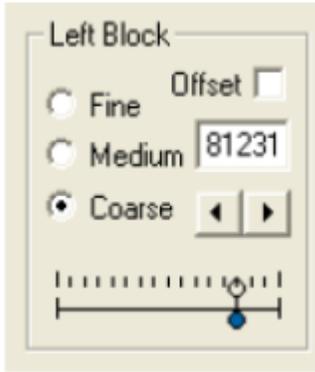
Figure 16 Fiber Image from Camera Tower

The camera image is fitted to the image window, which means that it may be squished or stretched horizontally and vertically. This becomes apparent when the circular end of a fiber is imaged and appears as an oval. To remedy this, right-click in the image window and activate the Horizontal Scrollbar and Vertical Scrollbar. Doing so will force every pixel from the camera to be treated as one pixel on the screen.

Right clicking in the image window also enables the user to turn the cross-hairs and alignment guides on or off and to save an image as a bitmap or a TIF.

5.9. Movement Control Bar

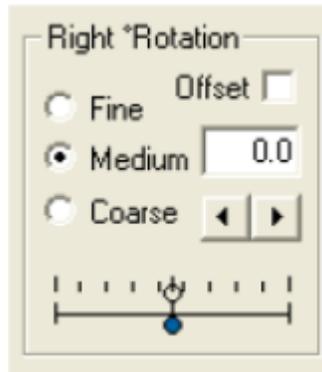
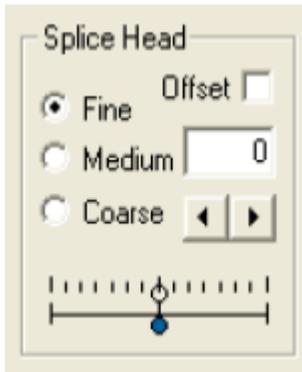
The seven boxes in the Movement Control Bar permit the user to move the fiber holding blocks and splice head at will by clicking on the forward and back arrows. The radio buttons labeled “Fine,” “Medium,” and “Coarse” allow the user to decide how much motion should occur with each click of an arrow. The indicators showing the positions of each element are given in units of motor steps.



Left Block: The Left Block box enables the user to move the left fiber holding block in and out. The number shown is the position of the left block in microns. The positive direction is defined as “in” towards the splice head. Thus, for the left block, positive motion is to the right.

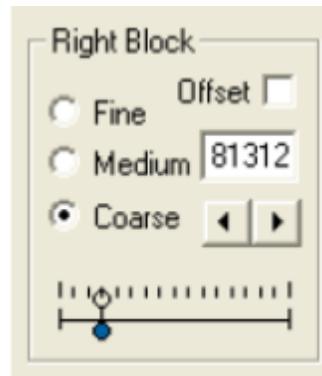
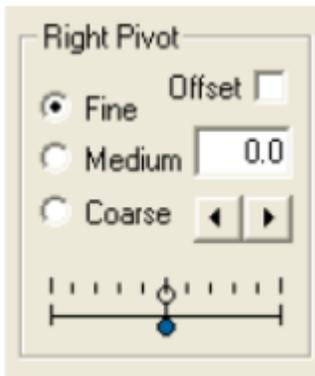
Left Pivot: The Left Pivot box enables the user to pivot the left fiber holding block for alignment in the back view.

Left Rotation: The Left Rotation box enables the user to rotate the left fiber in order to align stress members in PM fiber, align cores in eccentric-core fiber, or align surface features in non-circular fiber.



Splice Head: The Splice Head box enables the user to move the splice head left or right. Positive motion of the splice head is to the right.

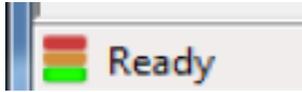
Right Rotation: The Right Rotation box enables the user to rotate the right fiber, for the same reasons one would employ left rotation.



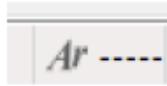
Right Pivot: The Right Pivot box enables the user to pivot the right fiber handler for alignment in the front view.

Right Block: The Right Block box enables the user to move the right fiber handler in and out.

5.10. Status Bar



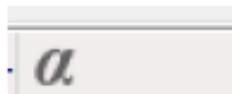
Status Window: This window indicates the status of the unit. When the bottom bar is green and the window reads “Ready,” the unit is ready to execute new commands. When the top bar is red, the unit is not responding and is either busy or needs to be initialized.



Argon Window: If the user double-clicks the argon window, the argon flow rate is reported in liters per minute. In the default state, this window is dormant.



Power Consumption: This window indicates power consumption; this function is normally dormant. If the user double-clicks it, the unit will periodically report voltage across and current through the splice head filament. Both the voltage and current are reported in ADC levels. The maximum for each is 65535, which corresponds to 5 V and 80 A respectively.



Cleave Angles: This window indicates the fiber cleave angles. The cleave angle measured on the left fiber is displayed on the left, and the cleave angle measured on the right fiber is displayed on the right. In order to get a reading of the angles, the user must perform an automatic alignment.



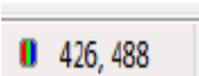
Fiber Rotation: This window indicates the rotation angle of each fiber relative to the horizontal plane..



This function not yet enabled.



Filament Fusion Timer: This window is a cumulative “on” timer for the Filament.



Cursor Location: This window indicates the position of the cursor within the image window.



Pixel Brightness: This window indicates the relative brightness of the pixel under the cursor when it is within the image window. Double-click on this to adjust the brightness of the illumination in the current view.

Chapter 6 Fusion Splicing

Fusion splicing is a process of joining two optical fibers end-to-end using heat. The goal is to fuse the two fibers together in such a way that light passing through the fibers is not scattered or reflected back by the splice, and the splice and the region surrounding it are almost as strong as the virgin fiber itself. This chapter will deal exclusively with the manner in which the LFS4100 can be used to perform high-quality fusion splices.

6.1. Filament Fusion



WARNING



The filament in the LFS4100 furnace generates intense light when it is in operation. It is strongly advised that the user NOT look directly at it during splicing or tapering operations.



CAUTION: HOT SURFACE



The furnace gets extremely hot when the filament turns on. Touching the furnace immediately after the filament has been on for a few seconds, such as after a splicing or tapering operation, is STRONGLY ADVISED AGAINST

The LFS4100 uses a graphite, tungsten, or iridium filament to provide the heat necessary to fuse fibers together. The filament is a resistive heater typically shaped like an upside-down omega that is open at the top. In the beginning of the process, the fibers are roughly positioned in the center of the camera viewing area. Depending on the alignment method selected, the LFS4100 software will use inputs from the CCD camera or an external optical power meter to precisely align the fibers. Computer-controlled stepper motors are used to position the fibers during alignment and to push the fibers together during the filament fusion.



WARNING



The fiber handlers and the splice head can exert a fair amount of force as they move from side to side. It is strongly advised that users NOT put their fingers between them, or between the fiber handlers and the slot end walls, while the machine is in operation.

After the software aligns the fibers, the splice head is repositioned to center the filament under the fiber ends. Power is then applied to the filament to raise its temperature to a level hot enough to fuse the fibers together, typically about 2000 °C. Because the filament would oxidize (burn up) if brought up to such a high temperature in air, an inert gas (argon) is used to purge the splice chamber of oxygen. In order to keep the fibers clean and improve splice strength, the purging gas is set to flow over the fibers at a fairly high rate during the fusion process. The fiber ends are allowed to heat up before they are pushed together. This smoothes over any discontinuities in the fiber ends and also increases the plasticity of the glass. The hot fibers are then pushed together, producing a splice with low loss and high strength. The splice properties can be edited in the Splice Property window, which can be accessed through Menu Bar, Splice, Splice Parameters, or by right-clicking on Splice Parameters.

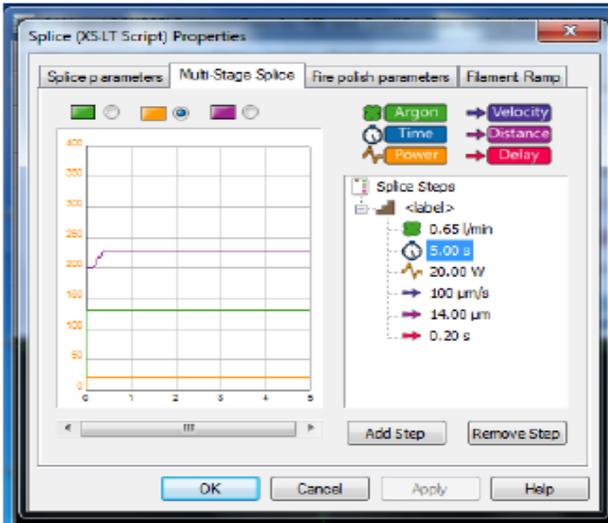
It is important to check the following items before beginning the splicing process:

- Splice Power:** This is the amount of power the filament will receive during the splice. Check the filament power displayed in the Splice Parameters window. To change the splice power, select the Power box and enter the desired splice power in watts. Refer to Table 2 for typical values.
- Splice Time:** This is the length of time the filament will receive power during the splicing process. Check the splice time displayed in the Splice Parameters window. To change the splice time, select the On-Duration box and enter the desired splice time in seconds. For silica-based fibers, splice times should be between 2 and 15 seconds, with 5-7 seconds typical for 125 micron fiber.
- Fire Polish:** The status of the fire polish process is displayed in the Fire Polish Parameters tab. If the power is set to zero then the fire polish is off.
- Pre-Push:** This is the distance the fibers are pushed together prior to the fusion process. Check the pre-push distance displayed in the Splice Parameters window. To change the pre-push distance, select the Pre-Push box and enter the desired distance in microns.
- Hot Push:** This is the amount the fibers are pushed together after being pre-heated by the filament. Check the hot push distance displayed in the Splice Parameters window. To change the hot push distance, select the Hot Push box and enter the desired distance in microns.
- Hot Push Delay:** This is the length of time the filament will heat up before the hot push is performed. Check the hot push delay displayed in the Splice Menu. To change the hot push delay, select the Hot Push Delay box and enter the desired delay in seconds. A value of 200 milliseconds is a good starting value for 125 micron fibers.

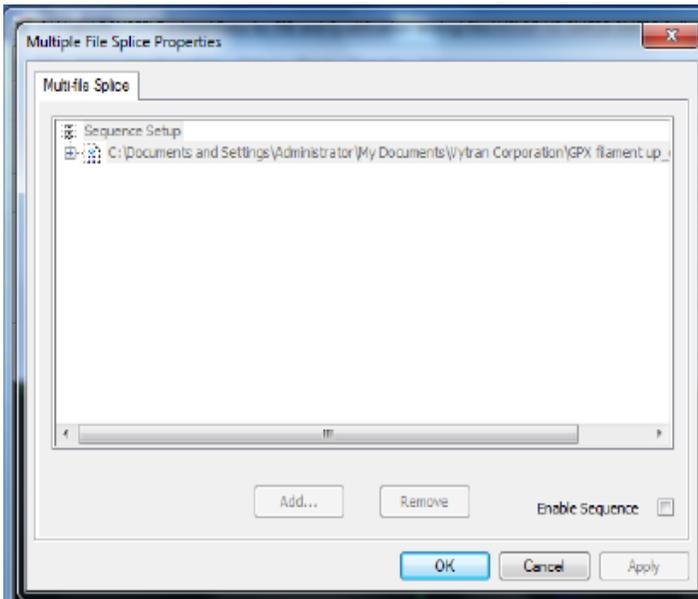
Fiber Cladding Diameter	125 μm	250 μm	400 μm	600 μm	1000 μm
Filament	FTAV2	FTAV4	FTAV4	FTAV5	FTAV6
Splice Power	58 W	66 W	120 W	132.5 W	190 W
Splice Time	7 s	7.5 s	8.5 s	10 s	12 s
Pre-Push	5 μm	5 μm	0 μm	0 μm	5 μm
Hot Push	14 μm	12 μm	30 μm	30 μm	40 μm
Hot Push Delay	0.2 s	0.6 s	1 s	1.2 s	1.8 s

Table 2: Typical Splice Settings

6.2. Multiple-Stage and Multiple File Splicing



For certain special applications, the system can run several splice steps in a sequence. Multi-stage splice options can be accessed from Menu Bar, Splice, Splice Parameters, Multiple-Stage Splice. Users can set up all the parameters for each splice step and add or remove splice steps in this window.



The system can also perform several splice files in a sequence. The multiple file splice options can be accessed through Menu Bar, Splice, and Multiple File Splice Setup.

Users can add or remove pre-saved splice files in this window. The system will perform the splicing function according to the sequence of the files in this window.

6.3. Fiber Alignment



WARNING



Similarly, the camera tower can generate a fair amount of force as it moves forward and back, and up and down. It is strongly advised that users NOT put their fingers between it and the furnace or mirror tower while the machine is in operation.

Before fusion, the two fibers to be spliced must be aligned by the edge, core, or end-view alignment methods using the images captured by the camera tower or by the active alignment method. The edge and core alignment methods use side view images to determine the positions of the fibers and align them in the XY plane. The end-view alignment method uses images of the fiber ends to automatically control both XY and rotational position. Alternatively, active alignment with an optical power meter can be used for fiber that has a high core eccentricity.

6.3.1. Edge Alignment

The edge alignment method aligns the edges of the fibers in the XY direction when the fibers are in front view and back view position. To use this method, the fibers must first be set to the pre-gap distance. This gap allows individual fiber movement and ensures proper identification of the fiber edges. The software then uses the image data acquired by the CCD camera to precisely determine the location of the fibers. This positional information is used to align the fibers by moving the stepper motor positioner. Successive images are analyzed and the fibers are repositioned until they are aligned.

6.3.2. Core Alignment

The core alignment method is similar to the edge alignment method, except the system attempts to align the cores of the fibers instead of the edges. This process can only be used where there is a clearly visible image of the fiber cores. It is also essential that the core image is not distorted by the fiber claddings.

6.3.3. End-View Alignment (PM Alignment)

The end-view alignment method is used for polarization-maintaining fibers such as 3M elliptical-core fiber (PM or PZ), Panda fiber, bow-tie style fiber, and for hybrid splices between any of these. These types of fiber require a rotational alignment in addition to an XY alignment.

The end-view alignment process is initiated by using the “Lens Left or Lens Right” process. This instructs the fibers to be pulled back so that a mirror can be inserted between the two fiber end faces. The image of the fiber ends is then displayed and the automatic alignment can also take place. For the automatic alignment to be successful, the PM alignment parameters must be correctly set to match each fiber type (as described below).

To make the LFS4100 perform PM alignment during a splice process, select the Alignment menu then select Enable PM Alignment. Then, select PM to display the PM Alignment Configuration window. This window displays two parameters for each fiber, as shown in Figure 17 below. The user must enter the correct fiber cladding diameter, the fiber type, and the two PM geometry parameters for each fiber. If the fibers are the same, then check the Same box. If the operator does not know the exact characteristics, it is possible to directly measure them on screen.

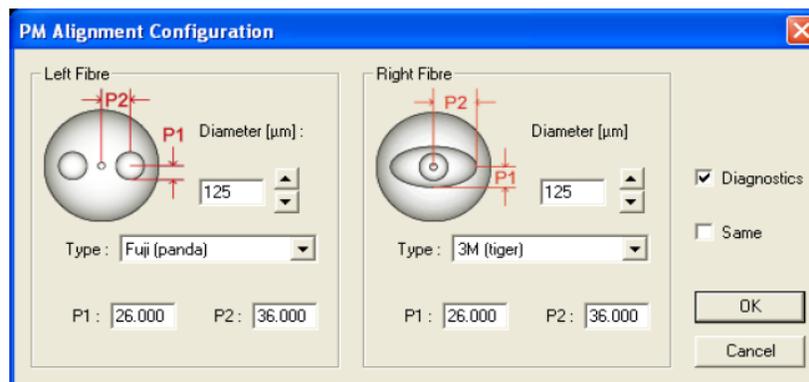


Figure 17 PM Alignment Configuration Window

Normally after the “Lens Left” process, a sequence such as, “Auto Exposure,” “End View Focus,” “Auto Exposure,” and then “End View Process,” would be inserted to align the fiber. If the operator is unhappy with the alignment, the process can be stopped and the fibers can be manually aligned.

Fiber Type	Parameter 1	Parameter 2
Generic	OD Ratio	N/A
Panda	Core Center to Stress Rod Center, (Pixels)	Stress Rod Diameter (Pixels)
Elliptical (3M)	Core Center to Edge of Ellipse, Minor diameter (Pixels)	Core Center to Edge of Ellipse, Major Diameter (Pixels)
Bow Tie (Fiber Core)	Core Center to Stress Rod Center (Pixels)	N/A

Table 3: PM Fiber Parameters

Note that “OD Ratio” represents the fraction of the fiber diameter which will be used to calculate the fiber end angle. It is the fraction of the fiber diameter that contains the PM Structure.

6.3.4. Active XY Alignment

The active alignment method should be used for fiber that has a high core eccentricity. In this case, the edge alignment method cannot ensure proper alignment of the fiber cores. Active alignment is a core-to-core alignment which uses output from an optical power meter to maximize the power transmission. Active alignment is implemented by performing the “Active Alignment” process after an “Align” process has been completed. The process first moves one fiber away from the aligned position and then back towards the stationary fiber to eliminate the motor backlash. A reference power meter reading is taken at this position. The fiber is then moved by a given scan step size and another power meter reading is taken. This continues until the fiber has scanned through the maximum power. The fiber is then driven back to the maximum power meter reading position.

6.4. Filament Normalization

Before using a new filament and when starting the equipment after a long period of inactivity it is necessary to perform filament normalization. This will adjust some parameters to ensure a high quality splice. Two key control parameters are the “view to splice distance” (to center the filament between the fibers) and the “power offset” (to have the same temperature).

In the filament normalization process, the fibers are heated without a hot push. This process burns back both fiber ends. The software then measures the level of regression of each fiber and compares it with a predefined value. The “view to splice distance” and filament “power offset” are then changed and reported by the software.

6.5. System Malfunction

If the system detects a critical problem during any operation, the Failure window will be shown and request input from the operator for further operation.



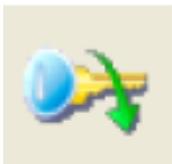
Abort: This button ends the current one button process.

Retry: This button runs the failed process a second time. If it fails again, the one button splice will end.

Continue: This button skips the failed process and executes the next process in the process list.

Reset: This button runs the reset macro. On completion, the user can choose to abort, retry, or continue.

6.6. Initialization and Shutdown



When the LFS4100 is turned on, it is necessary to press the Initialization button in order for the software to establish communication with the system. The initialization button is pictured to the left. Before initialization takes place, most of the buttons on the GUI will appear grey, and the status bar light will be dull red. The LFS4100 must be on for initialization to succeed.

Shutting down the LFS4100 requires no special sequence. Switch the LFS4100 off, turn off the vacuum pump, external supply, and argon supply, close the GUI, and then shut off the PC.

6.7. Storage and Transportation

When packaging the splicer for storage or transportation, the following precautions are necessary:

- Ensure that the lens assembly is at the home position.
- Attach the transport block to secure the lens in its home position. This is important to ensure that the lens system does not move during shipment.
- Disconnect all gas and electrical connections.
- Make sure that the foam is positioned properly in the original packing box.
- Lower the LFS4100 system carefully into the box.
- Position the foam insert over the top of the LFS4100 and then carefully close the top of the case.
- DO NOT PACK ANY OTHER ITEM WITH THE LFS4100. SEVERE DAMAGE WILL BE CAUSED TO THE SYSTEM IF THOSE ITEMS MOVE IN TRANSIT.

Chapter 7 Maintenance

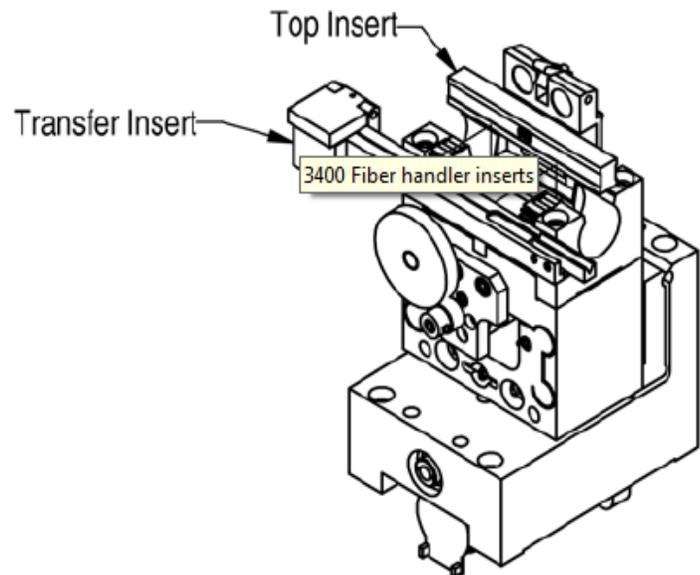
7.1. Fiber Holding Block Maintenance

The fiber holding blocks must be cleaned periodically to ensure accurate fiber positioning. It is also sometimes necessary to change fiber holding block inserts to accommodate different fiber sizes.

7.1.1. Changing the Fiber Holding Block Inserts

As discussed in Section 3.5.4, the lower insert in each of the LFS4100 fiber holding blocks is a special transfer insert designed to speed up fiber transport and positioning. This insert is normally held in place with magnets instead of setscrews. While there are three setscrews that can be used to clamp the transfer insert in place, they are not necessary for the system to function properly. If these setscrews are not used, the transfer insert can be quickly dropped in place after use in another compatible Vytran system.

However, the top insert *is* held in place with setscrews. These two set screws are located in the back of the lid and must be loosened before the top insert can be replaced.



7.1.2. Cleaning the Fiber Holding Block Inserts

Debris in the fiber holding block V-grooves may interfere with fiber positioning. The V-grooves should be cleaned carefully using a soft brush moistened with acetone.

7.1.3. Adjusting the Transfer Insert Clamp

The clamp at the end of the transfer insert can be adjusted to accommodate fibers of slightly different diameter. To do this, the user must first loosen the two setscrews in the back of the clamp and then adjust the setscrew in the bottom of the clamp. If the transfer insert is to be used with a smaller fiber, the user should turn the screw clockwise. If the transfer insert is to be used with a larger fiber, the user should turn the screw counter-clockwise. The side of the clamp should remain flush with the end of the insert. Once the correct block height has been reached, the two setscrews in the back of the clamp should be re-tightened.

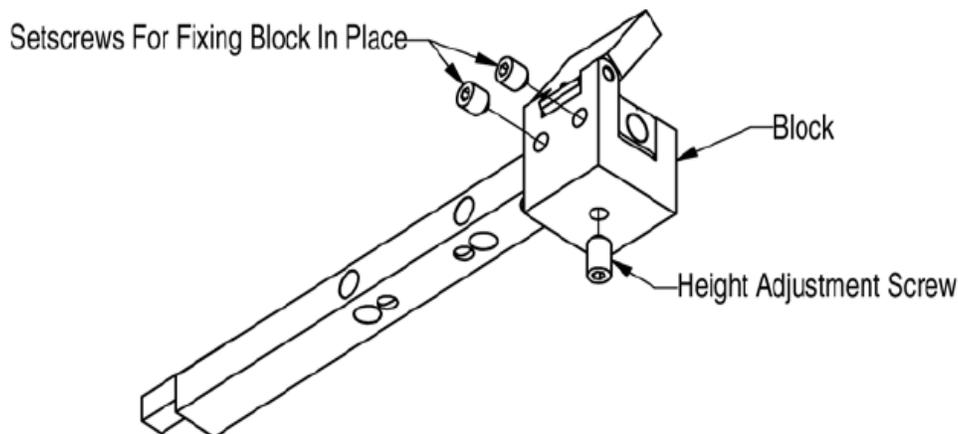
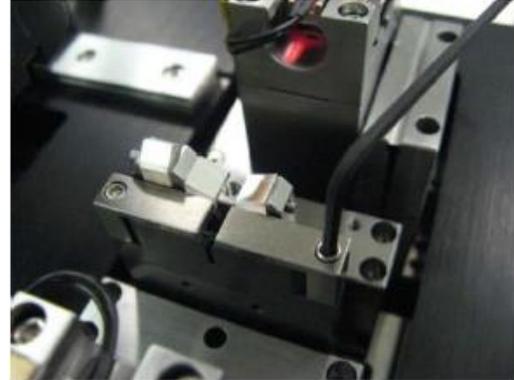
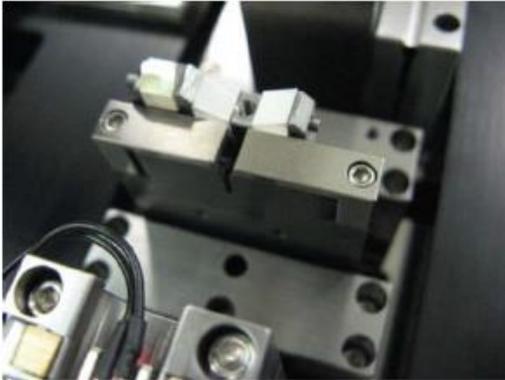


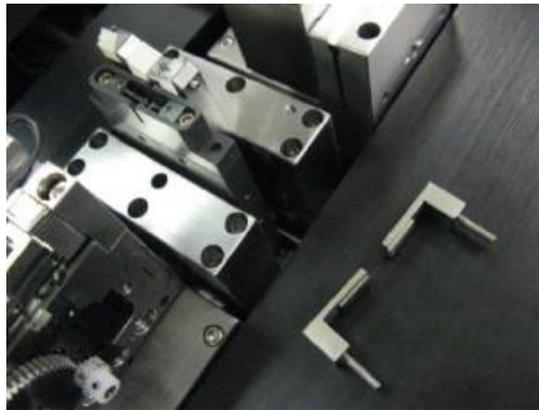
Figure 18 Location of Setscrews on Transfer Clamp

7.2. Filament Replacement Procedure

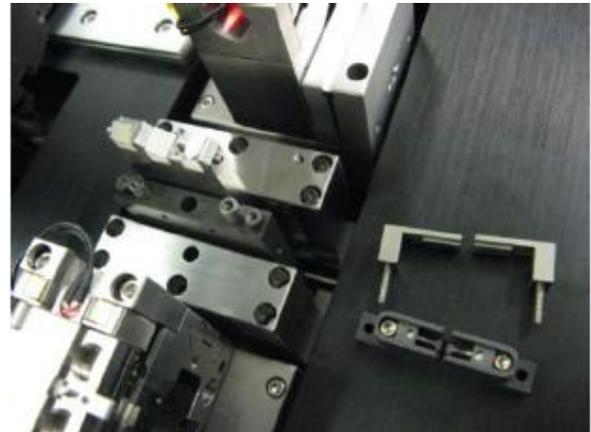
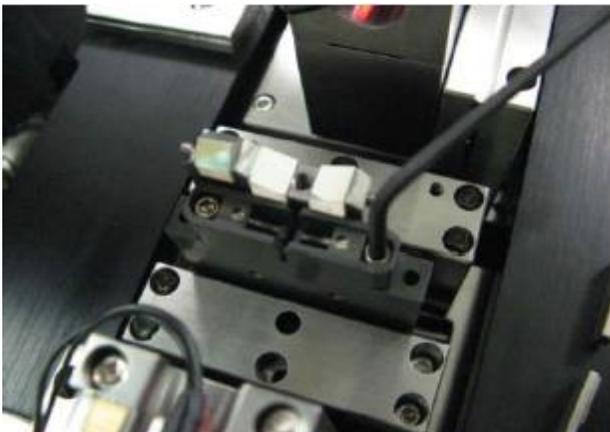
- Switch the LFS4100 on and initialize.
- Home the Fiber holding blocks by clicking on the “FHB Home” macro button.
- Home the lens by clicking on the “Lens Home” macro button.
- Switch the LFS4100 off.
- Remove the 2 screws (5/64” Allen wrench) that secure the stainless steel cover plates onto the furnace.



- Remove the Stainless Steel cover plates.

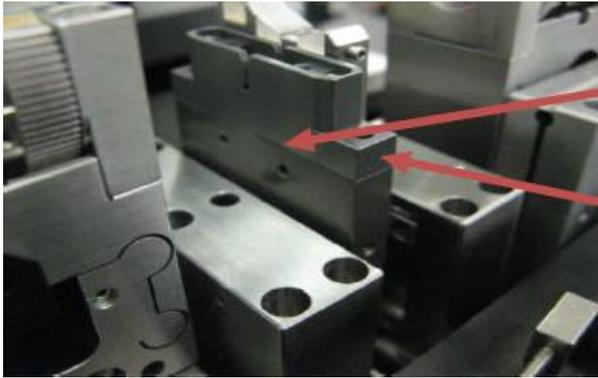


- Remove the 2 screws (5/64” Allen wrench) that secure the filament to the furnace body.



- Remove the filament body and replace with a new one. Be sure to have the filament “V” number inscription facing toward the front (user side) of the unit.

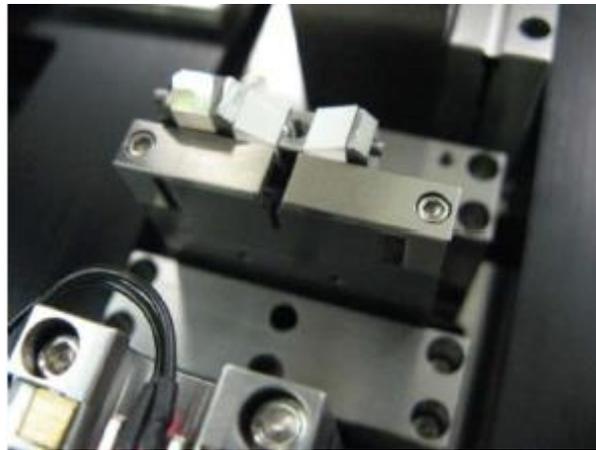
- Fit and secure the 2 screws that fasten the filament body to the furnace. Do not over tighten. Use a torque wrench set to 6 lb-in.



Make sure the filament body sit evenly front to back, no gap in between.

Letter faces front

- Re-fit the stainless steel cover plates and fasten.



- Switch the LFS4100 on, then initialize.
- Press “Load Fibers” to bring the fiber holding blocks to the load position.
- Load a fiber into the left and right fiber holding blocks.
- Move the lens to Back View
- Gap and align the fibers.
- Press the “Filament View” macro button. The LFS4100 will move the lens and the mirror to the left end view position.
- Raise the splice head by typing **5motorto (14 @14)** into the command window and hitting “Send.” It should now be possible to view the fiber position relative to the filament on the PC monitor.
- Shine an external light source into the fiber so that the end face is illuminated. It may take some adjustment to get the light and the fiber positioned correctly.
- Once the end face of the fiber is visible, move the fiber and/or the camera to bring the image of the fiber end and filament into focus. Moving the fiber is accomplished by clicking the arrows in the Left Block box. Moving the camera is accomplished by moving the slider in the Camera bar.
- Check that the filament is positioned in the center of the filament height-wise.
- Use the motor step command on motor 14 to adjust the splice head height (e.g. send **5motorstep (14 8)** to raise the splice head one micron). When the fiber is perfectly centered in the filament, record the position of the splice head (given in the traffic viewer window), and make this the new userdata 14 (e.g. **5setuserdata (14 78000)**).

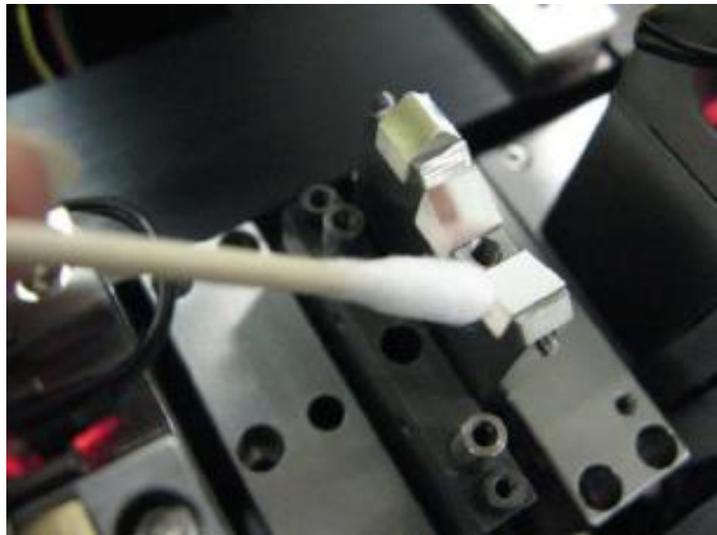
- To home the splice head vertically, press the “Filament Home” macro button. Then, type **5motorto (14 @14)** into the command window and hit “Enter.” View the image on the screen to make sure the fiber is still centered in the filament. If the position is OK, enter **5writeuserdata()** to make the change permanent.
- The user should also check that the filament does not contact the fiber when it is raised and lowered.
- If the filament does contact the fiber, check that the fiber is properly loaded in the fiber holding block V-grooves. Also check that the correct V-grooves are being used.
- If the filament position is alright, then send the lens home.
- Home the fiber holding blocks.
- The filament is now ready for normalization.

7.3. Cleaning the Mirror

The fiber image can be distorted by debris that accumulates on the mirror surfaces. This debris may be dust from the atmosphere, small pieces of fiber coating, finger prints, etc. Great care must be taken when cleaning the mirror surfaces, as they are all front silvered. If it is possible to visibly discern debris in the fiber image then the mirrors should be cleaned. If the focus processes are failing then that is also a sign that the mirrors may need cleaning.

Procedure:

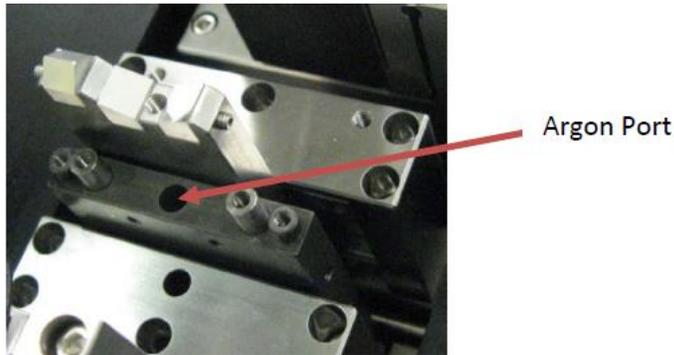
- Move the lens assembly to home.
- Move the fiber holding blocks to home.
- View each mirror surface using a 10x eye loop.
- Remove debris using a clean cotton swab and a commercial lens cleaner.
Note: The mirrors are front silvered. Only use clean cotton swabs. Never use a cotton swab that has been laying on the work surface. Dust particles will scratch the mirror.
- Wipe the mirror surface in a single direction, rotating the swab to lift debris away from the mirror surface. Do not re-use the Cotton swab.
- View the mirror through the eye loop. Re-clean if necessary.
- Repeat for all mirror surfaces as required.



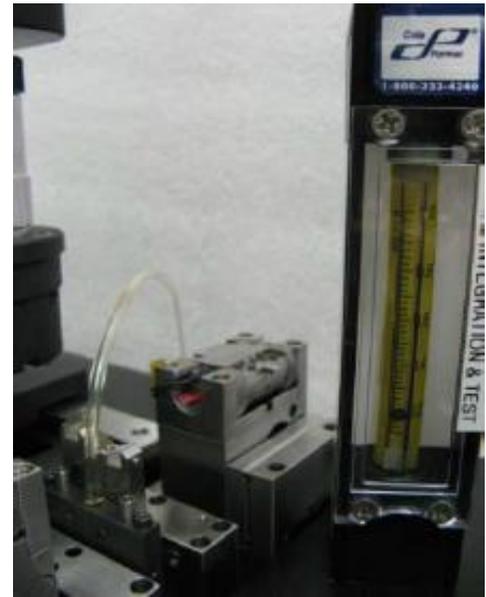
7.4. Measuring and Setting the Argon Flow Rates

The argon gas flow rate settings should be adjusted when switching between fiber diameters. The flow rate settings are set in the splice file. To check and/or calibrate the argon flow rates:

- Ensure that the system is on and the regulator is set to 9 – 11 psi.
- Remove the filament assembly according to the directions given in Section 7.2.



- Insert the flow meter tube end into the argon port shown above. Place the flow meter vertically on a solid surface for the most accurate reading.
- Select Configuration, Argon Flow Rates from the menu bar. In the pop-up window, set the desired flow rate. Initiate the purge using the Purge tool bar item. Wait 5-10 seconds for the flow meter reading to stabilize. Verify that the flow meter measures the set flow value. Reset the Purge flow rate to 2 l/min on completion of the test.



7.5. RMA Process

To return the unit for service, contact Thorlabs. Visit <https://www.thorlabs.com/locations.cfm> for contact information.

When returning the product to Thorlabs, please use the original packaging and pink anti-static bag that the unit came in.

The illustrations below show the correct way to re-pack the LFS4100. Please ensure that the bottom of the box is taped securely before re-packing the unit. If returning a malfunctioning unit for repair, we ask that you return the accessories with the unit in case one of the accessories happens to be the source of the problems.



Figure 19 LFS4100 Packaged for Return

Chapter 8 Fiber Holder Insert Selection Guide

Top Inserts:

The LFS4100 fusion splicer requires fiber holder inserts to be placed in the fiber holding blocks in order to clamp the fibers during the splicing process. Fiber holder top inserts sit in the lid of the fiber holding blocks and come in a variety of groove sizes. They can be used to clamp the cladding, coating, or buffer of a fiber. The top inserts and bottom inserts can be paired in a variety of combinations to accommodate all fiber sizes compatible with the LFS4100 splicer, as shown in Table 4. Multiple combinations of top and bottom inserts may be required to accommodate all sizes of fiber to be spliced.

There are two types of top inserts that are compatible with the LFS4100 fusion splicer. The standard top inserts (Item #'s starting with VHA) come in single-sided and double-sided versions; the specified fiber diameter (in μm) is engraved on the part. These top inserts cannot be used for end-view imaging. They are, however, compatible with the FPS300 Fiber Preparation Station, LDC Series of Fiber Cleavers, and GPX Glass Processing Systems. For end-view imaging and alignment, an insert with an indent for LED illumination (VHB00 or VHB05) is required. This mode of operation allows for alignment of the cores of polarization-maintaining, eccentric-core, and microstructured specialty fibers. These LED illumination inserts are also compatible with the GPX Series of Glass Processing Systems.

Fiber Holder Insert	Side 1 Accepted Diameter (Min / Max)	Side 2 Accepted Diameter (Min / Max)
VHB00	57 μm / 759 μm	N/A
VHB05	410 μm / 1008 μm	560 μm / 1269 μm
VHA00	57 μm / 759 μm	275 μm / 970 μm
VHA05	410 μm / 1008 μm	560 μm / 1269 μm
VHA10	812 μm / 1515 μm	1036 μm / 1770 μm
VHA15	1288 μm / 2022 μm	1534 μm / 2268 μm
VHA20	1772 μm / 2505 μm	2032 μm / 2944 μm
VHA25	2278 μm / 3029 μm	N/A
VHA30	2609 μm / 3198 μm	N/A

Bottom Inserts:

Fiber holder bottom inserts sit in the bottom section of the fiber holding blocks and come in a variety of groove sizes. They can be used to clamp the cladding, coating, or buffer of the fiber. The top inserts (sold above) and bottom inserts can be paired in a variety of combinations to accommodate all fiber sizes compatible with the LFS4100 splicer, as shown in Table 4 below.

There are two types of bottom inserts that are compatible with the LFS4100 fusion splicer. The bottom inserts for fibers with cladding or buffer diameters up to 1.047 mm (indicated with Item #'s starting with VHF) are transfer inserts; they allow for a single fiber to be transferred between the Vytran FPS300 Fiber Preparation Station, LDC400 Series of Fiber Cleavers, and LFS4100 Splicer without loss of positional reference. All of these transfer inserts require the VHT1 transfer clamp; the transfer inserts for diameters $\leq 550 \mu\text{m}$ also require a graphite V-groove.

Fiber Holder Insert	Side 1 Accepted Diameter (Min / Max)
VHF160	112 μm / 208 μm
VHF250	177 μm / 320 μm
VHF400	279 μm / 519 μm
VHF500	346 μm / 795 μm
VHF750	516 μm / 1047 μm

Fiber Holder Bottom Inserts for larger cladding or buffer diameters (indicated with Item #'s starting with VHE) come in single-sided and double-sided versions; the specified fiber diameter (in μm) is engraved on the part. These bottom inserts can also be used in the FPS300 Fiber Preparation Station, LDC Series of Fiber Cleavers, and GPX Glass Processing Systems. Positional reference of the fibers will not be maintained when these inserts are transferred between systems.

Fiber Holder Insert	Side 1 Accepted Diameter (Min / Max)	Side 2 Accepted Diameter (Min / Max)
VHE10	773 μm / 1271 μm	1034 μm / 1523 μm
VHE15	1280 μm / 1769 μm	1534 μm / 2007 μm
VHE20	1787 μm / 2267 μm	2033 μm / 2513 μm
VHE25	2270 μm / 2844 μm	N/A
VHE30	2692 μm / 3198 μm	N/A

The table below indicates the minimum and maximum diameters that can be accommodated by different combinations of top and bottom inserts. It also indicates how far offset the fiber will be for recommended combinations of top and bottom inserts. Note that this outer diameter may be the fiber cladding, jacket, or buffer. If one side of the fiber is being discarded, it is preferable to clamp onto the cladding of this section except in special cases (such as non-circular fiber) where the coating or buffer may be preferable. Sections of fiber that are not being discarded should always be clamped on the coating or buffer in order to avoid damaging the glass. This may require different sets of fiber holder inserts to be used in the left and right holding blocks. In this case, it is important to minimize the difference in the offsets introduced by the left and right sets of inserts when attempting to produce high quality splices.

1. First, select the bottom insert that matches your fiber size most closely.

Example: For an $\text{Ø}800 \mu\text{m}$ fiber, the VHF750 insert is the closest match, since it is only 50 μm smaller.

2. On the chart below, look to the right of your chosen bottom insert. Select a compatible top insert based on the fiber diameter size range shown in each cell. Green cells indicate the best fit, orange cells indicate the second best fit, and white cells indicate the third best fit.

Example: For the $\text{Ø}800 \mu\text{m}$ example fiber from step 1, the green cell is in the 750 μm groove column for the VHA05 and VHB05 top inserts, which have two grooves. The numbers listed in the green cell indicate that this combination of inserts is good for fibers from 728 to 963 μm in diameter. Our $\text{Ø}800 \mu\text{m}$ fiber is within this range, so this is a good choice. There are several other options that will accommodate an $\text{Ø}800 \mu\text{m}$ fiber as well, but the green shading in the chart indicates that the 750 μm groove in either the VHA05 or VHB05 provides the best fit. Of these two top insert options, the VHB05 is compatible with end-view imaging but the VHA05 is not.

3. The second line of numbers in each cell shows the range of offsets that can be expected for any given combination of top and bottom inserts. When selecting inserts for the right and left fiber holding blocks, try to minimize the offsets between the pairs of inserts on each side.

Example: If we choose a VHF750 bottom insert and the $\text{Ø}750 \mu\text{m}$ groove in the VHA05 top insert, we can use fiber as small as 728 μm , in which case the center of the fiber would sit 23 μm below the surface of the bottom insert. We could also clamp a fiber as large as 963 μm , in which case the center of the fiber would sit 213 μm above the surface of the bottom insert. We could interpolate to find the offset expected for our hypothetical 800 μm fiber, but it turns out that in a 60° V-groove, the offset is equal to the diameter difference. So, that means that the center of our fiber is going to sit 50 μm above the bottom insert surface because it is 50 μm larger than the fiber that the bottom insert was designed for ($800 - 750 = 50$).

4. Holding blocks designed for fibers less than 1000 μm in diameter have vacuum holes, designed to aid in aligning small fiber within the groove, while bottom inserts for fibers of $\text{Ø}1000 \mu\text{m}$ or larger do not have these holes.

The LFS4100 has a vacuum pump that provides a small holding force via these holes, keeping small fibers in place as the clamps are lowered.

Top Insert Item #	VHA00 VHB00	VHA00	VHA05 VHB05		VHA10		VHA15		VHA20		VHA25	VHA30	
Accepted Diameter (Nominal)	≤320 μm	400 μm	500 μm	750 μm	1000 μm	1250 μm	1500 μm	1750 μm	2000 μm	2250 μm	2500 μm	3000 μm	
Bottom Insert Item #	Accepted Diameter (Nominal)	Min/Max Accepted Diameter (μm) Min/Max Offset (μm)											
VHF160	160 μm	112/208 -49/48	-	-	-	-	-	-	-	-	-	-	-
VHF250	250 μm	177/320 -73/69	275/323 25/74	-	-	-	-	-	-	-	-	-	-
VHF400	400 μm	279/519 -122/119	377/517 -23/117	410/519 -9/119	-	-	-	-	-	-	-	-	-
VHF500	500 μm	346/592 -153/93	447/647 -53/147	476/711 -24/211	560/795 61/296	-	-	-	-	-	-	-	-
VHF750	750 μm	516/759 -234/9	617/970 -132/221	643/878 -107/128	728/963 -23/213	812/1047 62/297	-	-	-	-	-	-	-
VHE10	1000 μm	-	-	773/1008 -172/63	858/1093 -88/147	943/1178 -3/232	1036/1271 90/325	-	-	-	-	-	-
	1250 μm	-	-	-	1034/1269 -176/59	1119/1354 -91/144	1212/1447 2/237	1288/1523 78/313	-	-	-	-	-
VHE15	1500 μm	-	-	-	-	1280/1515 -172/63	1373/1608 -79/156	1449/1684 -2/233	1534/1769 82/314	-	-	-	-
	1750 μm	-	-	-	-	-	1534/1770 -159/76	1611/1846 -83/152	1695/1930 2/237	1772/2007 78/313	-	-	-
VHE20	2000 μm	-	-	-	-	-	-	1787/2022 -171/64	1871/2106 -86/149	1947/2183 -10/225	2032/2267 74/309	-	-
	2250 μm	-	-	-	-	-	-	-	2033/2268 -167/68	2109/2344 -91/144	2193/2429 -6/229	2278/2513 78/313	-
VHE25	2500 μm	-	-	-	-	-	-	-	-	2270/2505 -172/64	2355/2590 -87/148	2439/2675 -2/233	2609/2844 167/402
VHE30	3000 μm	-	-	-	-	-	-	-	-	-	2692/2944 -256/-4	2777/3029 -171/81	2946/3918 -2/250

Table 4: Recommended Fiber Ranges for Top and Bottom Inserts

Chapter 9 Specifications



CAUTION



Be sure your electrical power and gas supplies meet the criteria detailed in Chapter 9.

9.1. Electrical Power

The LFS4100 comes with an external power supply unit, which requires 90-260 VAC, 47-63 Hz, single phase. This external power supply provides the unit with a 12 V line and a 48 V line (10 A max).

The LFS4100 is controlled via a desktop computer. The computer serves as an interface between the user and the LFS4100. The laptop requires 115 or 230 VAC, 47-63 Hz, single phase.

9.2. Gas Supply

The LFS4100 splicing system uses high-purity argon gas to purge the splice chamber of oxygen during the filament fusion process. This is necessary to keep the fibers clean and to prevent the filament itself from oxidizing at the high fusion temperature.

Thorlabs supplies a high-purity PTFE gas line and a large gas regulator with the LFS4100. These are for use with a large gas tank (not supplied) which has a CGA-580 output port. Zero grade Argon gas with purity of > 99.999% is recommended; research-grade argon gas is preferred. Any other gas may damage the unit, (NOTE: European DIN fittings are supplied as required in European markets. An adaptor may be required to allow connection of the supplied CGA-580 output port to the gas tank fittings in other areas or countries).

Gas Supply Specifications:

It is recommended that only zero- or research-grade argon gas be used with the LFS4100. Any other gas may damage the unit or shorten the lifetime of the filament. Zero-grade argon is specified as 99.999% pure with $O_2 < 0.5$ ppm, $H_2O < 3.5$ ppm, and THC (Total Hydrocarbons) < 3.5 ppm. Research-grade argon is somewhat cleaner with specifications of 99.9995% purity with $CO_2 < 0.5$ ppm, $H_2O < 0.5$ ppm, $N_2 < 3.0$ ppm, $O_2 < 1.0$ ppm, and THC < 0.5 ppm.

When using a large tank of gas, be sure the regulator is set to approximately 9 psi. Do not exceed 25 psi under any circumstances. If no gas pressure is present at the input port, the splice station will interlock and the "Low Gas Pressure" message box will be displayed if operation of the filament is initiated.

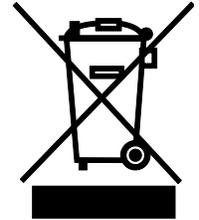
Use only a Thorlabs-supplied gas line to interconnect the regulator to the splicing system. If an extended length gas line is required between regulator and splicer, please contact Thorlabs for purity requirements and line specifications.

Chapter 10 Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

This offer is valid for Thorlabs electrical and electronic equipment:

- Sold after August 13, 2005
- Marked correspondingly with the crossed out “wheelie bin” logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated



Wheelie Bin Logo

As the WEEE directive applies to self-contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e.g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

Waste Treatment is Your Own Responsibility

If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

Chapter 11 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at www.thorlabs.com/contact for our most up-to-date contact information.



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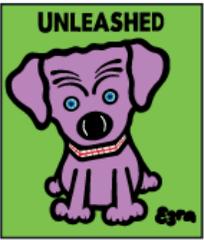
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